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GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA.
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR.

ANNUAL REPORT

(NEW SERIES)

VOLUME III.

PART I.

REPORTS A, B, C, E, F.

1887-88.

PUBLISHED BY AUTHORITY.

MONTREAL:
WILLIAM FOSTER BROWN & CO.
1889.

GEOLOGICAL & NATURAL HISTORY SURVEY,
Alfred R. C. Selwyn, C.M.G., L.L.D., F.R.S., Director.
MUSEUM AND OFFICE, SUSSEX ST. OTTAWA.

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GEOLOGICAL AND NATURAL HISTORY SURVEY

OF CANADA.

REPORTS AND MAPS

OF

INVESTIGATIONS AND SURVEYS.

THE HONOURABLE EDGAR DEWDNEY, M.P.,

Minister of the Interior.

SIR,—Herewith I have the honor to submit Vol. III, new series, of the Reports of the Geological and Natural History Survey of Canada. It consists of 13 parts or separate reports, with numerous maps and illustrations, relating to the geology, mineralogy and natural history of various sections of the Dominion from British Columbia to Nova Scotia.

The several parts were issued separately at intervals during the past twelve months, and can be purchased at from ten to thirty cents each.

I have the honour to be,

Sir,

Your obedient servant,

ALFRED R. C. SELWYN,

Director.

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA.

ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR.

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ERRATA.

Page 24 H, Title of Plate, *for* Outline *read* Outlyers.
Page 89 H, line 14 from bottom, *for* p. 72 H *read* p. 88 H.
" 111 H, side note, *for* vein *read* vein minerals.
" 124 H, line 12 from top, *for* per ton (200 lbs.) *read* per ton (2000 lbs.)
" 124 H, line 19 from top, *for* smelting and charges *read* smelting and other charges.
Page 9 J, line 17 from top, *for* Diner's *read* Viner's.
" 9 J, " 3 and 2 from bottom, *for* Gillan *read* Gillam.
" 10 J, " 5 from top, *for* Gillan *read* Gillam.
" 24 J, " 8 from top, *for* Omer's *read* Viner's.
" 28 J, " 17 from top, *for* island *read* inland.
" 33 J, " 19 from bottom, *for* face *read* base.
" 33 J, " 11 from bottom, *for* blackish *read* brackish.
" 34 J, " 7 from bottom, *for* fifty *read* fifteen.
" 35 J, " 9 from bottom, *for* areas *read* terraces.
" 37 J, " 14 from top, *for* Kitchisipis *read* Kitchisipi.
" 43 J, " 14 from bottom, *for* Kotaniwauan *read* Kotaniwanan.
" 44 J, " 21 from top, *for* Kabunskiwas *read* Kabunskiwao.
" 45 J, " 22 from top, *for* Kabunskiwas *read* Kabunskiwao.
" 45 J, " 2 from bottom, *for* Patilawagau *read* Patitanagan.
" 46 J, " 19 from top, *for* Patilawagau *read* Patitanagan.
" 50 J, " 14 from top, *for* Mishiminiwetan *read* Mishimimwetan.
" 50 J, " 8 from bottom, *for* Mishiminiwetan *read* Mishimimwetan.
" 54 J, " 8 from bottom, *for* light green felspar *read* light green hornblende.
" 55 J, " 17 from top, *for* Manitonieck *read* Manitounuck.
" 57 J, " 9 from bottom, *for* Saal *read* Seal.
" 75 J, " 2 from top *for* T. S. Cotter *read* G. S. Cotter.
Page 11 K, line 7 from top, *for gregori read gregoria,*
" 11 K, " 22 " " *for Helsophyllum read Heliophyllum.*
" 11 K, " 23 " " *for seriatula read striatula* (name preoccupied).
" 13 K, " 18 from bottom *for* Roulette *read* Rolette.
" 13 K, " 16 from bottom *for* à *read* de.
" 14 K, " 17 from bottom *for* à *read* de.
" 15 K, " 2 from bottom, *for Orthrograptus read Orthograptus.*
" 19 K, " 9 from top *for* Ancient *read* Indian.
" 19 K, " 2 from bottom *for Atrypa hemispherica read Camerella hemiplicata*
" 23 K, " 8 from bottom, *for Hyalostetia read Hyalostelia.*
" 35 K, " 4 from bottom, *for* Belleile *read* Belle Isle.
" 50 K, " 11 from top, *for folium read folium ?*
" 50 K, " 10 from bottom, *for brachiatus read quadribrachiatus.*
" 86 K, " 17 from bottom, *for* Marcelli *read* Marcel.

Page 86 K, " 8 from bottom, *for* de *read* du.
" 92 K, " 14 from top, *for* Les Saintes *read* Saints.
" 101 K, " 13 from bottom, *for* Meul *read* Meule.
" 101 K, " 9 from bottom, *for* Meul *read* Meule.
" 110 K, " 2 from top, *for* compresser *read* compressor.
" 10 M, " 4 from bottom, *for* explored *read* unexplored.
" 10 M, " 6 from bottom, *for* Ardovician *read* Ordovician.
" 10 M, " 12 from bottom, *for* nor *read* or.
" 17 M, " 14 from bottom, *for* 1°-20′′ *read* 10°-20′′.
" 27 M, " 6 from bottom, *insert* M *after* 41.
" 28 M, " 10 from bottom, *for* extentation *read* extention.
" 41 M, " 8 from bottom, *for* Trilobite *read* Crustacea.
" 45 M, " 3 from top, *for* there *read* thin.
" 46 M, " 1 from top, *for* subplanm *read* subplanum.
" 46 M, " 6 from top, *for* like *C. Clintoni*, Hall, *read* sp.

The tabulated list of the fossils, referred to in letter p. 3 M, is omitted.
Page 161 B, line 3 from top, *for* Lytton *read* Lilloet.

PLATES AND MAPS ACCOMPANYING THIS VOLUME.

PLATES.

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1. Index Map of Yukon District. Scale 60 miles to 1 inch. Part B.
2. Yukon District and part of British Columbia, 3 sheets. Scale 8 miles to 1 inch. Part B.
3. Geological Map of Cariboo Mining District. Scale ½ inch to 1 mile. Part C.
4. Island Mountain and Mosquito Creek. Scale 400 ft. to 1 inch. Part C.
5. Hixon Creek quartz locations. Scale 400 ft. to 1 inch. Part C.
6. Veins and "Placers" Hixon Creek. Scale 2112 ft. to 1 inch. Part C.
7. Sketch section from Guy's Mountain to the Cariboo Range. Part C.
8. Topographical Map of Duck and Riding Mountains, Manitoba. Part E.
9. Geological Map of Rainy Lake, sheet 3. Scale 4 miles to 1 inch. Part F.
10. Sketch Map of Thunder Bay Mining Region. Scale 4 miles to 1 inch. Part H.
11. Geological Map of Silver Mountain Mining District. Part H.
12. Quarter Sheet 17 N.E., Edmundston, N.B. Scale 4 miles to 1 inch. Part M.
13. Quarter Sheet 2 N.E., Miramichi, N.B. } Scale 4 miles to 1 inch. Surface
14. Quarter Sheet 6 S.W., Shippegan, N.B. } Geology. Part N.

NOTE.—No. 11 Map is not yet received from the engraver, and will be issued later.

SUMMARY REPORTS

OF THE

OPERATIONS OF THE GEOLOGICAL SURVEY

FOR THE YEARS 1887 AND 1888.

The following Summary Reports are reprinted from Part III. of the Annual Reports of the Department of the Interior, in which the reports and maps presented in this volume are referred to as well as others in course of preparation.

These will be issued during the season of 1889-90, and will together constitute Vol. IV., New Series, of the Reports of the Geological Survey.

1887.

As in previous years, the explorations of the Survey have embraced many parts of the Dominion, and have, during the past season, extended from Vancouver Island and the Alaskan and northern borders of British Columbia, to James' Bay and the Atlantic coast of Nova Scotia, as well as to portions of the provinces of new Brunswick, Quebec, Ontaria and Manitoba.

Much new and valuable geological and geographical information has been acquired, and large and interesting additions have been made to the Museum collection.

The Annual Report for 1886, Vol. II., new series, has recently been issued. This volume of 977 pages, R. 8vo., with numerous maps and illustrations, is composed of thirteen parts, or distinct reports, giving, in detail, the scientific and the practical information, and the conclusions arrived at respecting the various portions of the country explored, or on the other subjects treated of. The parts are also published separately, and are sold at an average price of twenty-five cents each.

My own time, during the early part of the year, after my return from England, at the end of December, 1886, was fully occupied in the preparation of the Annual Departmental report, with the general executive details of the Branch, and in connection with the preparation of of the Annual Report, Vol. II, above referred to.

During the summer, between the 13th June and the 10th of October, I visited and examined varied places, between Gaspé Bay and Cape Rosier in Quebec, and Vancouver Island in British Columbia, where the work of the Survey is in progress, and where some personal observation was required, either for information on points of economic importance, or in connection with the working out of the geological structure of the region. Of these may be mentioned: the occurrence of petroleum at Gaspé; the relations of the graptolite bearing rocks of Cape Rosier, Matane and Bic to those of Point Levis, the Island of Orleans and Quebec; the cupriferous pyrrhotite mines of Sudbury; the silver mines and the iron ores of the vicinity of Port Arthur; the coal mines of Lethbridge and of Banff; the silver-lead mines of Illicillewaet, in the Selkirk Mountains; and the hot springs of Harrison Lake and of Banff.

As regards the Gaspé petroleum, no efforts appear to have been made to develop it since 1863, and beyond the fact of the recent discovery of oozings at a point higher up Silver Brook than where the first boring was made, there is no further information about it now than was given in the Geology of Canada, 1863, pages 402, 521 and 789, and in the report by Dr. T. Sterry Hunt, published in 1865, "On Petroleum, its Geological Relations considered with special reference to its occurrence in Gaspé." Three borings appear to have been made, the sites of which are marked on the geological map, ¼ sheet, 6 N. W., but as none of them exceeded 200 feet, a successful result was hardly to be expected. The development of the extraordinarily massive, cupriferous ore bodies in the vicinity of Sudbury was being actively prosecuted by the company. The manager informed me that 2,000 tons of the ore had been shipped to the Messrs. Vivians, of Swansea, Wales, and on their report depends the question whether the Sudbury ores can or can not be profitably worked. This ore-belt has now been definitely traced for eight miles, and outcrops of large bodies of ore have been found at intervals throughout. In view of the immense quantity of ore, the small cost of raising it, and the facilities for shipping it, a very low price per ton would leave a fair margin of profit.

The argentiferous galena of Illicillewaet occurs chiefly in quartz veins, cutting a series of black carbonaceous or graphitic slaty shales, and thin bedded limestones, often much folded, but showing an average dip of from 35° and 40° to E.N.E., and apparently flattening towards the summits of the mountains. Most of the veins are parallel with the stratification, though not infrequently passing from one bed plane to that of another. The openings on Kennedy & Corbyn's claim, No. 2, above the north fork of the Illicillewaet River, and about 5,300 feet above sea level, on a precipitous mountain

side, show a massive quartz vein in an almost vertical attitude, cutting the black slates which are here almost horizontal. The quartz is impregnated throughout with galena and some pyrites, and is said to be very rich in silver. A large pile of ore had been extracted, but as the only present access to this mine is by a steep zig-zag ascent 3,000 feet from the Canadian Pacific Railway, at Illicillewaet, and then by a similar descent of 1,000 feet on the other side of the ridge, ore very much richer than the bulk of this appears to be would be required to enable this mine to be profitably worked. The vein has more the appearance of a gash vein than that of a true fissure or fault vein, the slaty rock on either side of the vein being continuous, and showing no evidence of vertical displacement. Mr. G. B. Wright gave me a number of specimens from some of the other claims, and those that have been analysed by Mr. Hoffmann, have given from 247·92 oz. to 816·67 oz. of silver to the ton. In one only was a trace of gold found.

The great elevation—from 2,000 to 3.000 feet above the railway—at which most of the present openings are situated, must be considered a somewhat serious disadvantage, but there seems no reason why, by careful and intelligent prospecting, the same veins should not be discovered at lower elevations and in close proximity to the railway. No fossils have yet been found in these slates, but they closely resemble the black graptolitic shales described by Mr. McConnell, p. 22 D, Annual Report Geological Survey, 1886, and may be of Cambro-Silurian (Ordovician) age.

Samples were procured from the two hot springs at Harrison Lake, British Columbia, and these are now being analysed. That of Banff has also been analysed by Mr. Hoffmann. It will be interesting to ascertain the difference in the mineral contents of these waters—the one rising from the crystalline rocks of the coast range of British Columbia, and the other from the palæozoic limestones of the Rocky Mountains.

In my last summary report I stated "that the requirements of the Survey in respect to increased museum and office accommodation become each year more pressing." I may now state that, as regards the office accommodation, the steps I recommended are being taken, and in a few weeks, four additional well lighted and commodious office rooms will be available. They are on the top flat of the adjoining building, which has been connected with the present offices, the communication being closed by double iron doors to minimize the risk of fire, a risk unfortunately always great in the present situation of the Museum, and one which, in view of the great and annually increasing value of the collections, and the impossibility of replacing them if destroyed, merits, I would respectfully submit, the serious consideration of the Government, with a view to its speedy removal.

Dr. G. M. Dawson, with Messrs. R. G. McConnell, B.A., and James McEvoy, B. Ap. Sc., as assistants, was engaged during the past season in an exploratory survey of the region of the head waters of the Yukon and its vicinity, including portions of the northern part of British Columbia, but for the most part in the territory to the north of the 60th parallel, which constitutes the provincial boundary. Dr. Dawson was placed in general charge of the expedition, which was carried out conjointly by the Geological Survey and Dominion Lands Branches of the Department of the Interior. He furnishes the following preliminary account of the work of the Geological Survey contingent—Mr. Ogilvie's report on his special work, in connection with the Dominion Lands Branch, appearing elsewhere:—

"The Yukon expedition was undertaken in consequence of the necessity of ascertaining the nature and extent of the developments of placer gold mining, which of late years has attracted an increasing number of miners into the almost unknown district bounded to the south by the northern line of British Columbia, and to the west by the eastern line of Alaska. On account of the remoteness and the isolated character of the region to be examined, and the known difficulties to be encountered in traversing it, much time and attention were devoted to obtaining, by correspondence and otherwise, all available information, and in making such preliminary arrangements as were possible. For assistance in these matters we are especially indebted to Mr. John Grant, M.P.P., of Victoria; to Mr. Robert Campbell, now of Manitoba, the original explorer of a great part of the region; to Mr. J. Wrigley, Commissioner of the Hudson Bay Company, and Mr. J. McDougall, of the same company.

"I must also express my sense of obligation to Mr. W. Ogilvie, D.L.S., in special charge of the instrumental measurement on the Lewis River and to the 141st meridian, for his ready and obliging co-operation, and to Messrs. R. G. McConnell and James McEvoy, of this Survey, for their efficient assistance, to which is due much of the success of the expedition in carrying out the pre-arranged programme of work.

"We left Ottawa on the 22nd of April, travelling by the Canadian Pacific Railway to Victoria, but, in consequence of irregularity in the sailing dates of the Alaskan mail steamers, were unable to reach Wrangell, at the mouth of the Stikine River, where our work may be said to have begun, till the 18th of May. Here Mr. McConnell stayed behind, for the purpose of getting Indians and canoes to enable him to make a micrometer survey of the Stikine from the end of the line measured by Mr. J. Hunter, in 1877, to Telegraph Creek, while I proceeded up the river by the first steamer of the season to Telegraph Creek, the head of navigation. From this place goods are carried by

pack animals to Dease Lake, the centre of the Cassiar mining district; and here again a delay of several days occurred, as the animals had not been brought in from their range or shod for the season's work at the date of our arrival. Finally, on June 5th, we reached the head of Dease Lake, and found the greater part of the lake still covered with ice. It was not till the 9th that we were able to reach the point on the shore near Laketon, at which two men, previously sent on in advance with an Indian packer, were sawing lumber for boats. Seven days were here busily employed in this work and in constructing three boats for the purposes of the expedition. On the evening of the 16th, a strong wind having broken up the remaining barrier of ice, we reached Laketon with our boats, Mr. McConnell, with a crew of five coast Indians intended for my work on the Upper Liard, having meanwhile joined us. On the 18th, having completed our supplies and outfit at Laketon, we left that place, and on the 23rd reached 'Sylvester's lower post' at the confluence of the Dease and Liard Rivers. Here Mr. McConnell, with one boat and two men was to separate from us for the purpose of surveying and geologically examining the Lower Liard. In consequence of the delays experienced I thought it advisable to instruct Mr. McConnell to make arrangements, if possible, to winter at Fort Simpson, on the Mackenzie, as this would allow him to spend at least an an additional month in exploration in the autumn, besides enabling him to begin work to great advantage next spring, by descending the Mackenzie and crossing by the Rat and Porcupine Rivers to Yukon, thus obtaining a much more complete knowledge of the geology of the basin of the Upper Yukon than would otherwise be possible. This action on my part, I am happy to say, has since met with your approval, and advices have been received from Mr. McConnell since my return, to the effect that he had successfully accomplished the work on the Liard and had made arrangements to make his headquarters for the winter at Fort Providence.

"On leaving the confluence of the Dease and Liard, my own party included, besides myself, Mr. McEvoy, Messrs. L. Lewis and D. Johnson, engaged at Victoria, two Tshimsian and three Stikine Indians, all good boatmen. Two local Indians, hired as guides, and to help on the long portage, deserted a day or two after engaging, and from the lower post, to near the confluence of the Pelly and Lewis, for an interval of more than six weeks, we met with neither whites nor Indians.

"The ascent of the Liard and Frances Rivers to Frances Lake proved unexpectedly difficult and tedious, the water being swift throughout and three bad cañons having to be passed through. Frances Lake was reached on the 8th of July, and after spending a few days in examining and mapping the lake, making the observations necessary to fix its

position, and in the endeavor to find some Indian trail by which we might travel across to the Pelly, we began the work of portaging on the 17th.

"As we had been unable to discover any route now in use by the Indians, and no trace whatever remained of the trail employed by the Hudson Bay Company in former years, and as no local Indians could be found to act as guides or to assist in carrying our stuff, it was evident that the crossing of this portage (which had been estimated by Mr. Campbell at about 70 miles in length) would be a difficult matter, and that we might indeed find it impossible to carry over a sufficient supply of provisions for further work on the Pelly. We, therefore, constructed a strong log *câche* on the shore of Frances Lake, and left there to be taken back to Laketon by the Indians when they returned, everything we could possibly dispense with. Had we been unable to effect the portage, there was in our *câche* an ample supply of provisions to enable the whole party to return to the mouth of the Dease River. After a very toilsome journey, we were, however, so fortunate as to reach the bank of the Pelly on the 29th of July, with still nearly a month's provisions for four persons, the necessary instruments, and a small camping outfit, a canvas cover from which a canoe might be constructed, and the tools and nails for building a wooden boat, should that prove to be necessary. Our Indians, who had for a long time been very uneasy because of their distance from the coast and the unknown character of the country into which they had been taken, were here paid off, and to their great delight allowed to turn back.

"As a dangerous rapid was reported to exist on the upper part of the Pelly, it was decided to construct a canvas canoe in preference to building a boat, which it might prove impossible to portage past the rapid. Having completed the canoe, we descended the Pelly, making a portage of half a mile past Hoole's Rapid or Cañon, and reached the confluence of the Lewis branch of the Pelly (or Yukon) on the 11th of August. We had now reached the line of route which is used by the miners, and expected to find, at the mouth of the Lewis, a memorandum from Mr. Ogilvie, from whom we had separated in May. As we could not find any such memorandum, and as Mr. Lewis had not been seen on the lower river by a party of miners whom we met here on their way up the Lewis, we were forced to conclude that he had not yet reached this point. The same party informed us that few miners were during the summer on the Stewart River, where most of the work had been carried on in 1886, but that in consequence of the discovery of "coarse" gold on Forty Mile Creek, about 120 miles further down the river, all had gone there, and that Harper's trading post, where I had hoped to be able to get an additional supply of provisions should we fail to con-

nect with Mr. Ogilvie, had also been moved from the mouth of the Stewart to Forty Mile Creek. From the place where we now were we still had a journey of over 400 miles to the coast, with the swift waters of the Lewis to contend against for most of the distance. If, therefore, it should have become necessary to go down stream 220 miles to Forty-Mile Creek for provisions, so much would have been added to our up-stream journey that it would become doubtful whether we should be able to afford time for geological work on the Lewis and reach the coast before the smaller lakes near the mountains were frozen over. I therefore decided to set about the building of another boat, suitable for the ascent of the Lewis, and on the second day after we had begun work, Mr. Ogilvie very opportunely appeared. After having completed our boat and obtained Mr. Ogilvie's preliminary report and survey sheets, together with the necessary provisions, we began the ascent of the Lewis, from the head waters of which we crossed the mountains by the Chilkoot Pass and reached the coast at the head of Lynn Canal on 20th September. I am happy to be able to add that the entire expedition was carried out without any serious accident or loss, notwithstanding the difficult nature of the country, and that, though circumstantial reports were heard in the spring of trouble between the miners and Indians on the Yukon, these proved to be entirely groundless.

"The geographical, geological and general results of the work are now in process of elaboration and will be made the subject of a detailed report at an early date. Mr. Ogilvie's instrumental survey, now doubtless completed to the intersection of the river with the 141st meridian, will form a sufficiently accurate base line for future exploration in the region. In addition to this, the geographical results include the completion of an instrumental survey of the Stikine to Telegraph Creek by Mr. McConnell, which is connected with Dease Lake by a carefully paced traverse by Mr. McEvoy. Thence, a detailed running survey was carried by the route previously outlined, following the Dease, Liard and Pelly rivers and connecting with Mr. Ogilvie's line at the mouth of the Lewis River, a total distance of about nine hundred miles. Taken in connection with Mr. Ogilvie's measured line, these surveys include an area of over 60,000 square miles, the interior of which is still, with the exception of reports received from a few prospectors and from Indians, a *terra incognita*. The same remark, with little qualification, may be applied to the whole surrounding region outside the surveyed circuit, but much general information has been obtained respecting the entire district which will facilitate further explorations. The whole region is more or less mountainous, though intersected by wide areas of flat or rolling country. The north-eastern margin of the belt of coast mountains may be said to be at Telegraph

Creek on the Stikine. A second important mountain range runs in a general north-west by south-east course to the east of Dease Lake and is cut through by the Dease River. To the east of this no high or well-defined range was met with till the vicinity of Frances Lake was reached. Here a range, which may be accepted as the western part of the Rocky Mountains proper, is found with a similar trend to the east, and in this the streams feeding Frances Lake and the Pelly River rise. On the lower Pelly and Lewis Rivers the mountains are less considerable and assume a direction approximating more nearly to east and west.

"The following heights, deduced from a series of observations at a few main points will serve to indicate the general elevation of the country —

	Feet.
Telegraph Creek, Stikine River (water level)............	540
Dease Lake	2,661
Confluence of Dease and Liard Rivers......................	2,100
Frances Lake..	2,577
Pelly River at "Pelly Banks" (water level)........	2,965
Old Fort Selkirk, mouth of Lewis River (water level).	1,555
Lake Lindeman, head of Lewis River	2,165

"Till the observations made in the field have been laid down on the map it will be impossible to give with precision any account of the geological features of the region. The rocks in general are closely analogous to those met with in the corresponding region in British Columbia to the south. The coast mountains where crossed by the Stikine and by the Chilkoot Pass consist for the most part of granitoid rocks, with some included crystalline schists precisely similar to those found to the south in the same mountain belt, some details in connection with which are given in my last report on Vancouver Island. *

"To the east of the coast mountains, on the Stikine and Lewis Rivers, there are Palæozoic rocks resembling those provisionally classed in the southern interior parts of British Columbia as the Câche Creek series. They include limestones, quartzites, slates and schists, with a notable proportion of agglomerates and other materials of volcanic origin. In the vicinity of Dease Lake, and nearly on the same line of strike on the Pelly, important beds of serpentine occur, and the associated rocks in these and many other places are preponderantly schistose and slaty, running through numerous varieties, but closely resembling the rocks of the Cariboo and other goldbearing districts to the south.

* Part B, Annual Report Geol. Surv. 1886, V. II.

"These Palæozoic rocks are by far the most widely spread in the entire region so far as exploration has yet gone, but are interrupted by areas of granitic rocks which generally form ridges or mountain ranges, and these in some places are flanked by more or less important developments of crystalline schists which are probably, at least in part, altered portions of the Palæozoic. The most important granitic range met with in the inland region is that previously mentioned as crossing the Dease River.

"Fossils are by no means abundant in the Palæozoic rocks, but a small collection of graptolites, of Cambro-Silurian age, were obtained on the Dease River, and Carboniferous forms were observed in connection with the limestones in several places. It is quite probable, however, that rocks ranging from the Cambrian to the summit of the Palæozoic, and possibly extending also to the Triassic, may be included in this great series, of which the schistose and slaty members constitute the gold-bearing rocks of the country.

"Rocks which are probably of Cretaceous age occur in limited basins on the Stikine immediately east of the coast mountains, and beds holding Middle or Lower Cretaceous marine fossils have a considerable development on the Lewis River, where there are also plant-bearing beds referable to the horizon of the Laramie and probably of the same age as the so-called Miocene of the Alascan coast and Mackenzie River. A few fossil plants which are probably Cretaceous in age were also found at one place on the Pelly River.

"The Miocene proper is represented in the Upper Liard valley by soft stratified rocks, associated with basalts, and basaltic overflows, probably of the same age, occur on the Pelly, near the mouth of the Lewis, on the latter river at the Cañon, and in the Stikine valley east of the coast mountains. In the last mentioned locality are some remarkable examples of superposed columnar flows overlying coarse gravel deposits There is not, however, in the entire region examined, any wide basaltic plateau.

"Some features of special scientific interest occur in connection with superficial deposits and the evidences of glacial action, but these cannot be detailed here. It may, however, be stated that in both the Lewis and Pelly valleys traces of heavy glacier-ice moving in northward and north-westward directions, are often apparent. The grooving and furrowing is found equally well marked at the water level, and at the summits of hills several hundred feet in height, and appears to indicate the northward movement of a confluent glacier, in conformity with the general slope of the country. Terraces are of general occurrence and well developed, and often appear at considerable heights on the mountain sides. In connection with the distribution of placer

gold, the direction of ice movement in the glacial period is of special importance.

"As the main object of the expedition was the exploration of the Yukon basin, but passing notice could be taken of the Cassiar mining district. The rich placer mines in the vicinity of Dease Lake were discovered in 1872, and reached their maximum productiveness in 1874, in which year they are reported to have yielded about $1,000,000. The yield in succeeding years has gradually declined, but about 150 men are still annually employed in the district. Much prospecting still remains to be accomplished before the possibility of the discovery of new rich creeks is exhausted. Promising deposits of quartz are known to occur, though nothing has yet been done towards their investigation and development. These seem to be worthy of special attention in consequenee of the comparative accessibility of the district by means of the Stikine. It would be easy to construct a waggon road from the head of navigation on the river to Dease Lake, and a railway may eventually be expected to follow this route into the interior.

"Gold mining in the Yukon district may be said to have been initiated in 1880, though little was done in that year, except a certain amount of prospecting by twenty-five or thirty miners who entered by way of the Chilkoot Pass. Since then a yearly increasing number of miners have entered the country by the same route, and river bars have been worked with good results on different parts of the Lewis and its tributary the Teslin-too (Newberry of Schwatka, Hootalinqua of the miners), and on the Pelly and Stewart rivers. In 1886 most of the work was done on the Stewart, but in consequence of the discovery of 'heavy' or 'coarse' gold on Forty-mile Creek, as previously mentioned, nearly all the miners went to that place last summer. This is the first discovery of 'coarse' gold in the district, but it may safely be predicted that many more will follow. Prospecting has so far been confined almost exclusively to the larger rivers, and the mining to river-bar mining, but the fact has been developed that gold occurs in greater or less quantity on all the streams, and the extent of the gold-bearing river bars already known is, in the aggregate, almost unprecedented. The number of men engaged in mining on the upper Yukon last summer was about 250, of which about 100 are wintering in the country. The number likely to be employed next season can only be guessed at, as so much depends on the demand for labor on the west coast generally. It is not impossible, however, that at least 500 men will be at work.

"In comparison with the region now known as an auriferous one on the upper Yukon, the productive portions of the Cassiar mining dis-

trict are small, as profitable work there was practically confined to a few creeks, yet in 1876 the transit trade at Wrangell, in connection with the mining in Cassiar amounted in value to about a million dollars. This may serve as an index of the probable commercial results of a similar development of placer mining alone in any portion of the Yukon territory.

"The prospective value of the Yukon district and northern part of British Columbia as a mining region I believe to be great. This region includes—measured from the vicinity of Dease Lake to the intersection of the Pelly (Yukon) witb the 141st meridian—a length of over 500 miles of the Cordillera belt of the west, which, wherever it has been examined, has been found rich in minerals and particularly in deposits of the precious metals. The width of this particular part of the Cordillera belt is also great, as it appears, so far as our explorations have gone, to extend from the coast to the eastern ranges of the Rocky Mountains in the vicinity of the Mackenzie River. This portion of the Cordillera region, together with that of the more southern part of British Columbia, gives an aggregate length of between 1,200 and 1,300 miles, almost exactly equal to the length of the same metalliferous belt contained by the United States, and in all probability susceptible of an eventual mining development equally great.

"The general climatic features of the region explored and their relation to its orography cannot be entered into in this preliminary note. It must suffice to say that the very humid conditions of the coast do not extend to the interior, which includes some tracts of very dry country, and in the mountains of which glaciers occur rarely, if at all. Wheat, barley and patatoes are grown, on a limited scale, at Telegraph Creek and in its vicinity on the Stikine, though irrigation is necessary. Farther north, summer frosts are probably almost everywhere too frequent to admit of the growth of wheat, but I feel satisfied that barley and rye, with other hardy crops may be grown as far north as the 63rd parallel in the Yukon basin. The country, though generally mountainous in character, includes large tracts of flat or slightly broken land, and is, in fact, one which may eventually support a population as large as that found in corresponding latitudes in Europe (as, for instance, in the province of Vologda in Russia). It is for the most part wooded, and produces much timber of very fair quality, while open hill sides and terraces with bunch grass and aspen thickets occur along the river valleys. Large quantities of fine furs are yearly exported from the Yukon district, reaching the coast by the Chilkat and Chilkoot Passes, Taku and Stikine Rivers, or crossing to the Mackenzie by the Porcupine and Rat Rivers.

"One of the most important features of the Yukon district is the facility which the various large rivers, converging to form the main stream, offer for travel and inter-communication. These afford means for prospecting and exploring the country, and the distances to which they may respectively be ascended by boat or canoe has not yet, in most cases, been determined. It may be stated, however, that the rivers navigable for sternwheel steamers in Canadian territory have an aggregate length (measured without reference to minor flexures) of considerably over 1,000 miles, in which but one serious break of about three miles occurs on the Lewis. This length will be added to when the upper reaches of the larger streams are examined beyond the rapids or cañons, which are, in the above estimate, considered as defining the head of navigation in each case.

"Over 120 photographs were taken along the route followed, representing the character of the country, and I am happy to say that nearly the whole of these have proved satisfactory on development. Meteorological observations were kept up as regularly as possible, and numerous observations for latitude and longitude were made. Such geological and botanical specimens as appeared to be of interest were brought back, but in consequence of the difficulties of transport the weight of these had to be kept down as much as possible."

Cost of season's exploration of both parties, $4,832.46.

Mr. R. G. McConnell intended to send out a preliminary report on his examination of the lower part of the Liard River, above referred to, by the Hudson Bay winter packet, from Mackenzie River, but as this has failed to arrive in time to be included in this report, the following extracts from letters addressed to Dr. G. M. Dawson may serve to give an outline of his work.

In the first, sent back to the Pacific coast with his men, and dated Liard River, July 27, he writes:—

"I have now got down nearly to the mouth of the Nelson, and have just met some Hudson Bay men ascending the river. I am sending my two men back with them as the river is good from here, and I can drift down to Fort Liard, even if I cannot find an Indian to go down. I send them back from here because there is no chance of getting supplies either at Fort Liard or Nelson House, and if I took them on to Fort Simpson they could not get back this autumn, as the river is still booming and shows no sign of going down, and we have just about enough food left to last them to their *cáche* at the Devil's Portage. I shot two moose on the way down and that kept our supply up. We had a bad time getting down, as the river is a regular cascade for over a hundred miles. Between the Little Cañon and forty miles below the Devil's Portage it falls over 1,000 feet, and as forty miles of this

is good water you may imagine the state of the rest. It would be bad enough if it had room to flow, but it is penned in by cañons, often less than 150 feet wide, every few miles, and then whirls and boils in an incredible manner. We worked our way by sheer muscle, carrying both boat and stuff through forests and over high hills. My men turned out well and worked without a grumble. As for myself, I have hardly a stitch of clothes left, as they were torn to pieces and left hanging on the brambles and roots along the many portages. I hope that you have worked your way through your many difficulties, and have got out to the coast again. But you have a tremendous task before you, which I can appreciate now better than in the spring."

In the next letter, from Fort Smith, Slave River, under date August 23rd, Mr. McConnell writes:—

"After leaving the men, I floated down alone as far as Fort Liard, and there got an Indian to take me down in a bark canoe to Fort Simpson. At Fort Simpson I found the steamer, and came up as far as this place in her. This is rather a hard country to winter in without sending in supplies beforehand, as the deer have deserted it, and the people have been on short commons since last March. I am making arrangements to stay at Fort Providence, as it is a good locality for fish, and one will always have something to fall back upon. It is, besides, below Slave Lake, the ice on which is the great impediment to getting down the Mackenzie early. * * I am going down Slave River in a canoe, and on the way I will go up Salt River to the ridge in which it heads. From the mouth of Slave River I purpose going up Hay River to the falls, about 100 miles. I may also go up Buffalo River if I have time. During the winter I will try to visit Horn Hills, and see the country about Fort Rae. I believe Sir John Richardson is right about the Palæozoic age of the shales between Fort Simpson and this place."

A box of fossils, sent out at the same time with the letter from which the above extracts are taken, has since arrived. The fossils show the presence of Devonian, Triassic and Cretaceous rocks on the Liard River.

Mr. Amos Bowman was occupied the whole season in preparing and in supervising the lithography of the maps of his field work in British Columbia during the seasons of 1885 and 1886, chiefly in the Cariboo district, the survey of which, as stated in my report last year, was undertaken in connection with the Provincial Government. It was then, December, 1886, anticipated that the work of reducing the measurements and preparing the maps for publication would have been completed early in 1887. It has, however, together with the preparation of the report on the district, occupied till the close of the year. Both maps and report will be published at an early date.

In Manitoba, Mr. J. B. Tyrrell commenced a geographical and topographical examination and survey of the Riding and Duck Mountain region. He was assisted during the season by Mr. D. B. Dowling. We had very little precise knowledge respecting this district, but were aware of the occurrence in it of salt springs, gypsum deposits and strong indications of petroleum. It was also thought possible that workable seams of coal or lignite and natural gas might be found there, and in view of its proximity to navigable waters and to railways, it was considered important that it should be thoroughly explored. Mr. Tyrrell reports as follows: "We left Ottawa on the 5th July and reached Brandon on the 14th, where the horses used last year on the Calgary and Edmonton survey had previously been brought by rail. Men and supplies having been obtained, the party left Brandon on the 15th of July, following the trail northwards to Strathclair, situated in range 21, township 17. Thence an odometer survey was made up the Little Saskatchewan River, across the Riding Mountains and down the Vermilion River to Lake Dauphin. From the trails, paced surveys were made of the beds of Ochre River and Edward's Creek, the banks of these streams being either too swampy or too much obstructed by fallen timber to admit of following them, except on foot.

An odometer survey was then made northward across Wilson River to Valley River, a track survey being at the same time made of the Wilson River and its vicinity. North of Valley River, one of the rounded gravel ridges, known to the Indians as "pitching ridges," was followed first with a buckboard and odometer and afterwards on horseback as far as Fork River, a fairly accurate sketch-map being at the same time made of the eastern face of Duck Mountain. Finding that progress would be very slow north of Fork River, we returned to Valley River and made an odometer survey of the cart trail leading westward along this stream, passing through the gap that separates the Duck from the Riding Mountains in a wide glacial valley leading down into the Shell River, from which the trail was followed and surveyed over the high ground southward to the village of Russell, a terminus of one of the branches of the Manitoba and North-Western Railway. From Russell, a similar survey was conducted across Silver, Bird Tail and Arrow Creeks to Shoal Lake, and thence to Little Saskatchewan River, returning by a more northern route to the point of starting. From Russell we proceeded northward with buckboard and carts to Asessippi, on the Shell River, from which point the vehicles were sent round to meet me higher up the river, while with saddle and pack horses I examined the lower part of the valley, and rejoined the carts about the south line of township 26. We then continued up Shell River, to within three miles of the confluence of the north and

east branches, generally in the bottom of the wide deep valley, but sometimes we were obliged to climb to the top of the bank where it was impossible, without great delay, to ford the stream. On the way, however, we left Shell River for a time and turned westward on an Indian cart trail to Angling Lakes, where Coté's band of Indians have several houses in which they spend the winter, being here in the centre of their hunting grounds. From this village, then quite deserted, a track survey was made of the stream that flows northward into the largest and most eastern of the Angling Lakes till it flowed out of the valley that separates the Duck and Riding Mountains. It was found to be the main branch of Valley River. Two pack trails leading northward from the Indian village were also examined, one being found to lead up the west branch of Valley River to its source, and the other to "The Lake that does not freeze," and the latter of which belongs to the drianage area of Shell River.

Returning to this latter river, we were obliged to leave the carts at a point three miles below the confluence of the north and west branches and to use pack horses in continuing the survey towards the sources of some of the small streams tributary to the main river. Returning to the carts, we followed and surveyed an Indian cart trail northward across Big Boggy and Little Boggy Creeks, till it joined the old Pelly cart trail at the Indian village on Coté's Reserve. We then followed and located the latter trail northward to Fort Pelly, where we arrived on the 22nd of September. Having here obtained sufficient supplies to last till the end of the season, we followed a cart trail to the north-east, keeping north of Swan River for about forty miles, or till we reached the "Square Plain," making an odometer survey throughout the distance. I, however, branched off from this trail, and with pack horses followed a trail up Rolling River, till the stream became very small, and was flowing in a shallow valley through a country that appeared to be one interminable swamp. As the country was impassable for horses, I returned and made a paced survey down the bed of the stream to a short distance below the crossing of the old location of the Canadian Pacific Railway, where the river again flows in a defined but winding channel through a marshy, level tract of country.

Returning to Square Plain, Swan River was crossed and followed on its northern bank down to the mouth of Oak Creek, where the carts were again left, and with pack and saddle horses a track survey was made around the north end of Duck Mountain, following, during part of the distance, conspicuous gravel ridges that extend along the eastern face of the escarpment, at least so far north as the Valley of Swan River. In returning, the north-east point of the Duck Mountain was crossed, and also the head-waters of North and South Duck

Rivers and Pine River. Then passing around the north end of Big Lake, in which Rolling River takes its rise, the head of Favell River was reached. This river was then followed on a northward course to near its junction with Rolling River, returning thence to the carts at the mouth of Oak Creek.

While I was engaged as above described, Mr. Dowling was making pace and track surveys of Swan River and of the country lying north of it in the vicinity of the camp.

Below Oak Creek an odometer survey was made of the trail down to Swan Lake, and the river was followed on foot in many places, where there was any possibility of exposures of the underlying rocks being met with. From Swan Lake, the party returned to Fort Pelly by the old Hudson Bay Company's cart trail on the north side of Swan River, at the same time making an examination of the southern face of Thunder Hill.

The village of Russell was reached and the season's work completed on the 7th of November. Arrangements were made for the care of the horses and outfit for the winter before leaving for Ottawa, which we reached on the 14th November.

The surveys, which were checked throughout by latitudes taken with an eight inch sextant, will be plotted at once, and material will thus be furnished for an approximately correct map of a part of the country that, up to the present, has been almost entirely unknown.

Readings were taken regularly three times a day from a mercurial barometer, and numerous intermediate readings were taken from two aneroids, and as these will be compared with readings taken from a standard mercurial at Minnedosa, the height of which is known, it is hoped that the altitude of all important points can be determined with sufficient exactness to show the general slope of the country and the height of most of the important elevations.

The geological structure of these so-called mountains, as far as seen, is very simple. They are composed of practically horizontal dark-grey clay-shale, interbedded with bands of chalky limestones and bands and nodules of hard sandstone. These beds contain fossils characteristic of the Niobrara and Benton sub-divisions of the Cretaceous of Meek and Hayden's Nebraska section, and it is not improbable that some of the lower beds, which on Swan River were found to be sandstones and clays, represent their lowest, or Dakota Group, but no fossils were found to corroborate this, and no break or unconformity of any kind was found between any of the beds.

In some places, as on Vermilion and Ochre Rivers, the dark shales were found to contain a small quantity of mineral oil, and it is quite possible that borings may reveal reservoirs holding this oil in consider-

able quantities. No coal seams of any value, though carefully sought for, were found.

This subject and the geological structure of the district will be treated of in a detailed report to be prepared during the winter, after the observations and collections have been studied and the measurements plotted. About 1200 lineal miles of survey were made, and the observations covered an area of 3200 square miles of territory within the province of Manitoba.

The surface of the country is almost everywhere underlain by an irregular deposit of till, varying from a very thin crust to a massive bed several hundred feet in thickness. East of Duck Mountain its surface on the lower lands is generally level or slightly sloping, to the west it is generally more or less undulating, while on the summit of the mountain, and on the upper parts of its eastern slope there are many areas covered by moranic ridges, consisting of high drift knolls, thickly overstrewn with gneissoid boulders, between which are deep, rounded hollows, often holding small lakes of beautifully clear water.

Most of this latter country is practically valueless for agriculture, but considerable areas of it are covered with valuable forests, which by careful cutting could be made to yield a continuous supply of timber; but much of this rough land, especially that towards the north, is so thickly covered with boulders that it appears unable to bear more than a few scattered and stunted scrub pines. The undulating land to the south and west of the Duck and Riding Mountains is at present partly covered with groves of poplar, between which are more or less extensive areas of grassy prairie. This country is admirably suited for agriculture, since the soil is rich and well drained, and wheat can be raised with very little danger from early frost, certainly as far north as Big Boggy Creek, and perhaps as far as Fort Pelly. But perhaps the most fertile part of the whole district is that which lies between Dauphin Lake and the foot of Riding Mountain, where the underlying till is covered with rich layers of alluvial sand and clay. The land slopes gently towards the lake and is drained by several clear streams that flow from the face of the mountains. The area is partly wooded, the surface being covered with a rank growth of grass, weeds and rose-bushes, and dotted with groves of willow and poplar. Towards the north it is continuous with the swampy country lying between the gravel ridges east of Duck Mountain, though even here there are many rich meadows. Still further north, in the Swan River valley, meadow land again forms the greater portion of the surface, bearing a close growth of tall fine grass.

Near the headwaters of the Shell and Valley Rivers, between Rolling and Favell rivers, on the northern face of Duck Mountain, as well as

on some of the streams flowing from its eastern slope, there are some large areas covered with excellent white spruce averaging from 10 to 20 inches in diameter. Much of that on Shell River can be floated down into the Assiniboine River, where it can be sawn and distributed, but the rest must be floated into Lake Winnipegoosis. From there it must be conveyed to Lake Manitoba before it can reach a market, but this will be a very easy matter when communication is once opened through the narrow neck of land in the vicinity of Meadow Portage. Of late years fires have been doing very great damage to the forests of this region, and it certainly seems advisable that some more stringent measures should be adopted to prevent the occurrence of the conflagrations that periodically sweep over such large areas throughout northern Manitoba.

Fossils were collected from the Cretaceous shales and limetones, and also a small but interesting collection was obtained from beds of preglacial or en-glacial age, near the summit of Duck Mountain. Numerous specimens of recent mammals, birds and insects were also collected.

Sixty-six photographs were taken during the season illustrative of the geology and general surface of features of the country examined.

Cost of exploration, $1,741.16.

In April, correspondence was entered into with Major Powell, director of the United States Geological Survey, with a view to joint action in carrying out the survey and delineation of the glacial Lake Agassiz in its continuation into Manitoba. The terms of this joint action were agreed upon, and on the 6th May, Major Powell wrote expressing his "gratification at this inauguration of international work."

On the 11th September, Mr. Warren Upham, to whom the work was entrusted by Major Powell, wrote as follows:—"I have the honor to report the successful completion of the examination of the glacial Lake Agassiz in its continuation north of the international boundary in Manitoba, done under the auspices of your survey jointly for a detailed report to be made by me to you during the coming winter, and for my monograph on the subject for the United States Geological Survey. The cost of this exploration was $344.88."

Mr. Upham's report will form part of the next Annual Report.

Mr. A. Lawson left Ottawa for the field accompanied by Mr. Smith as assistant on the 27th of May, to continue the exploration and survey of the country between the Lake of the Woods, Rainy Lake and Lake Superior.

The work was commenced in the vicinity of Rainy Lake, and during the months of June, July and August, Messrs. Lawson and Smith

were occupied in making the surveys and investigations necessary to complete the maps of the Rainy Lake and the Rainy River districts. These maps cover an area of 5,182 square miles. They will be similar to that of the Lake of the Woods, published with Part CC of the Annual Report, 1885, though on the smaller scale of four miles to one inch. The information for these maps is now in course of compilation in the office, and the maps will be prepared for publication, together with a detailed report, during the winter.

After completing the field work, and before commencing the survey of the intervening country east of Rainy Lake, it was deemed desirable to make a further general reconnaisance of the geological features of the Thunder Bay district and the vicinity of Port Arthur, where latterly mining interests have been rapidly developing. The remainder of the season was accordingly devoted to this work and to a visit to the Vermilion Lake and Gogebic iron ore districts in Minnesota, for the purpose of comparing the geological conditions which obtain there in connection with these deposits, with those of the Thunder Bay district, in many parts of which there are geological indications inducing the belief that valuable deposits of iron ore exist there like those above referred to. While Mr. Lawson was thus engaged, Mr. Smith continued the topographical work on the north side of Hunter's Island, in the vicinity of the international boundary.

Mr. Lawson's party was in the field four and a half months. Average strength five men. About 700 miles were measured by micrometer, log survey and compass triangulation.

Cost of exploration, $1,608.97

Mr. A. P. Low, accompanied by J. M. Macoun as assistant, was engaged during the summer in making an exploration of the islands of James' Bay. No suitable craft for the work could be obtained at Moose Factory. A Lake Huron fishing boat was therefore purchased at Collingwood and sent to Missinabie station, on the Canadian Pacific Railway, situated on Dog Lake, at the head of the Michipocoten River. From here the boat was taken across the height of land and down the Missinabie branch of the Moose River to James' Bay, Moose Factory being reached 27th June. Leaving Moose 2nd July, the first island visited, called Charlton, lies near the southern end of the bay and about one-third of the distance across from the eastern shore. This island was found to be wholly made up of sand, clay and boulders, without any rock in place, and further investigation on the other islands visited showed that they were all of the same origin. Charlton Island is the second island in James' Bay in regard to size, being in shape an irregular oblique parallelogram, the diagonals being 18 miles from N.E. to S.W., and 12 miles from N.W. to S.E.

On the south side the shores are low and swampy, covered with a dense growth of black spruce and tamarac of small size; on the other sides the shores are high, and inland the island is a rolling plateau, with a light sandy soil, supporting a larger growth of white spruce and poplar. While on Charlton Island, a paced survey was made on the shore of Danby Island, which lies about one mile to the eastward. It was found to be roughly triangular in shape, each side being about two miles long. The whole island is low and flat, and covered with small black spruce and tamarac. On 11th July the party crossed to the Strattons, two small islands lying N. 65° E. from the north-east point of Charlton and ten miles distant. The western or larger is five miles long from E. to W. by about one mile and a half broad; the smaller is nearly round, with a diameter of one mile and half.' The interior of the larger island has an elevation of seventy-five feet above sea level.

Little Charlton Island was next visited, distant eighteen miles from the Strattons in a N. N. W. direction.

From Little Charlton a northerly course was taken through the Tiders, several small low islands, the larger covered with low bushes, the smaller being merely sand and boulder shoals, stopping at Watson Island, which lies N. 33 E. from Little Charlton in latitude 52° 31·07".

This island in form resembles a thin crescent, the greatest length being eight miles from north to south. With the exception of a few stunted white spruce, no trees grow on the island, its sand and boulder surface being covered with small arctic flowering plants, grasses and sedges. Continuing northward, Solomon's Temples, a number of low, sandy shoals, were passed, and the Twins, two large islands lying north and south, and separated by a channel five miles wide, were reached. These islands have the same barren character as Watson. After the Twins, Walter and Spencer, small islands lying to the eastward, were examined, and the mouth of the Big River reached 19th July. Here the party divided, Mr. Low going up the river, while Mr. Macoun explored the Lead and Bear Islands to the northward. The Big River was ascended fifty miles in an easterly direction. This is the largest river flowing into the east side of Hudson Bay, and is navigable with large boats for twenty miles from its mouth. It flows in a valley from one-third to one mile wide between cut banks from thirty to one hundred feet high.

The surrounding country is covered with a dense growth of trees in the following order as regards quantity: black and white spruce, tamarac, balsam and aspen poplar, balsam spruce and banksian pine; there are numerous outcrops of rock along the shores, the most common being a dark grey hornblende-gneiss.

Leaving Fort George, 2nd August, the bay was crossed by way of the Twins, and the island of Agoomski reached.

This is the largest island in James' Bay, being about seventy miles long from N. W. to S. E. by an average of ten miles broad.

Unlike the other islands, its coast line and interior are low and swampy and the interior is covered with small spruce and tamarac. From Agoomski the party returned to Moose Factory and thence by the Missinabie River reached the Canadian Pacific Railway 7th September.

The coast line and islands, as laid down on the Admiralty chart, do not agree with the Hudson Bay Company's chart, especially on the east coast, and further, neither the size, shape nor position of the islands visited by Mr. Low agrees closely with that given on either of the charts.

Mr. Macoun made several interesting additions to the collections of plants and insects.

Total cost of the exploration, $3,179.00.

In December last Mr. E. D. Ingall visited the salt districts of Ontario for the purpose of investigating the present condition of that industry, and to gather statistics and other information relating to it. This work was continued by means of correspondence, after his return to Ottawa on the 5th of January. He was then engaged completing a report on the subject, and also one on the silver production of Canada, both of which are published in the Statistical Report on mineral production in Canada, Part S of the annual volume for 1886.

The preparation of the latter report, examinations for which were commenced in 1885, was much delayed last year by the preliminary work with Mr. Coste in connection with the arrangements for the collection of the mining and mineral statistics.

After the completion of this work, Mr. Ingall commenced the preparation of the maps and other illustrations to accompany his report on the silver mining district west of Port Arthur, and on the geological features connected with the very rich silver-bearing veins of that district. At the same time arrangements were being made to commence an exhaustive investigation and survey, during the approaching summer, of the apatite mining districts in Ottawa county, province of Quebec, with a view to the preparation of a monograph on the apatite deposits and their developments.

In pursuance of this plan it was decided to make an accurate delineation of the rocks associated with these deposits over an area of about 200 square miles, so outlined as to embrace the most important mines of the district, thus including parts of the townships of Portland, Der-

ry, Buckingham, and Templeton. Mr. Ingall was assisted by Mr. J. White, who on the 22nd June commenced the preliminary topographical measurements requisite for the construction of a map, on which to lay down the geological features and the position of the worked and the unworked apatite deposits. At the same time Mr. Ingall made a tour of inspection of the principal mines, and then returned to Ottawa to continue work in connection with his report on the silver bearing district above referred to, leaving Mr. White to continue the work in the field. This was unfortunately brought to a close on the 11th of August by a serious accident, in which Mr. White had his leg broken and was otherwise so seriously injured as to incapacitate him for any work during the rest of the season. Under these circumstances, Mr. Ingall disbanded the party, and has since devoted his time to the completion of his monograph of the Thunder Bay, Lake Superior silver mines, of which the publication is now in progress.

Cost of the work in the field, $860.24.

Dr. R. Bell was engaged during the summer in an exploration of a portion of the large tract of but little known country on the confines of the provinces of Quebec and Ontario, including Lakes Temiscaming and Abbittibbi, the Montreal River and the upper waters of the Ottawa. The chief objects of the exploration were to ascertain more precisely the northern extension and the distribution of the great mineral bearing belt of Huronian rocks which commences on the Georgian Bay of Lake Huron and crosses the Canadian Pacific Railway at and in the vicinity of Sudbury, also to investigate the question of the northern limit of the apatite or phosphate and mica bearing belts of Ottawa county, and likewise to make such additions as might be possible to the existing very imperfect geographical knowledge of the region to be traversed.

Dr. Bell was assisted in the field during the summer by Messrs. A. E. Barlow and A. S. Cochrane; by the former from the 16th July to the 1st October, and by the latter from 8th September to the 28th of October. The exploration extended from the 11th July to the 18th of October, when Dr. Bell returned to Ottawa.

Dr. Bell furnishes the following summary of the season's operations:—

"Although the watershed to Hudson Bay was crossed both in the eastern and in the western extension of the exploration, the country examined may be described as the Upper Ottawa country, as the waters used as the bases of our operations, both east and west of Lake Temiscaming, fall into the Ottawa River.

"Fort Temiscaming was selected as headquarters for the summer."

The examination of the rocks of Lake Temiscaming was in continuation of the work of Sir W. E. Logan, in 1845, the result of which is summarized in chapters IV and XII of the Geology of Canada, 1863, and where also the succession of the Laurentian and the Huronian rocks on Lake Temiscaming is described. In the report for 1845 the rocks are more fully described, but they were not then known as Laurentian and Huronian.

Dr. Bell now states :—"This lake is surrounded by Huronian rocks and these were re-examined in the light of the knowledge of the Huronian system which has been gained since the time of Sir W. Logan's visit in 1845. The Silurian limestones, &c., of the islands and of the northern part of the lake were also examined and a considerable collection of their fossils was made. It is believed that the limits of the Silurian area at the north end of the lake can now be defined with tolerable accuracy.

"The course of the main Montreal River is singularly straight; its upward bearing is about north-west, and the distance from the mouth to the Great Bend, near which it divides into two branches flowing from the south, is 85 miles in a straight line. In 1875 I examined both these branches and the country thence to Lake Mattagami, in connection with a geological exploration, extending from the Wanapitai and Sturgeon Rivers, but the main Montreal River, below the Bend, had not hitherto been examined geologically. The rocks along it were found to belong to the Huronian system, except in two parts, namely at Bass Creek, two miles above the head of Elk Lake and just below the extremity of Sinclair's Line, or four miles below the junction of the East Branch, where Laurentian gneiss was met with.

"From the Great Bend of the Montreal River I crossed the height of land northward and descended the Frederick House River, a branch of the Abbittibbi, to Paish-ko-tchagami Lake. All the rocks seen on this route also belong to the Huronian.

"On returning from this exploration I descended the Montreal River to its junction with the northern outlet of Temagami Lake, and made a track-survey and geological examination of the lakes through which it flows. The rocks on this route were found to consist principally of clay-slates, argillites and quartzites, At the time of my visit to Temagami Lake, Mr. Barlow was engaged in making a micrometer and compass survey of it, having begun this work on the 23rd July, and he completed it about the end of September, after which he made a similar survey of the route from Temagami Lake *via* Rabbit Lake to the foot of Lake Temiscaming. Temagami Lake was found to measure about thirty miles in its greatest extent, or from north to south, and nearly the same from east to west, but much of its general area is

occupied by peninsulas and islands. It is remarkable for having two outlets which discharge its waters, the one into the St. Lawrence and the other into the Ottawa. The southern outlet is a branch of the Sturgeon River, which flows into Lake Nipissing and thence by the French River into Lake Huron; while the northern outlet, as already mentioned, falls into the Montreal River and thence into the Ottawa. The rocks around Temagami Lake embrace felsites holding pebbles of syenite (which are the most abundant), quartzites, clay-slates, massive diorites and crystalline schists.

"After having made a geological reconnaissance of Temagami Lake, I returned to Fort Temiscaming by way of Rabbit Lake and the Mattabatchawan River, and found the rocks along this route to consist principally of felsites and clay-slates.

"The Rivière Blanche and the travelled canoe route from Lake Temiscaming to Abbittibbi Lake were explored geologically by the late Mr. Walter McOuat in 1872, * and during the present year Mr. E. B. Borron, on behalf of the Government of Ontario, made an exploration of the region lying to the southward of the latter lake and he has kindly promised to furnish me with notes of his geological observations. We are indebted to Mr. Edward Haycock and to Mr. David Beatty, P.L.S., for additional information on the rocks of the Rivière Blanche and neighborhood.

"The next division of the season's operations consisted of the exploration of the region between Lake Temiscaming and the source of the Ottawa. Accompanied by Mr. Cochrane I proceeded from this lake by way of Kippewa, Birch, Sasiganaga, Wolf and Grassy Lakes to the Grand Lac du Moine, and thence to Grand or Victoria Lake of the Ottawa. Laurentian gneiss was the only rock observed on this route all the way from the foot of Lake Temiscaming.

"From Grand Lake Mr. Cochrane was sent northward to ascertain whether or not the Huronian belt, which crosses the canoe-route between the height-of-land and Lake Abbittibbi, extends eastwardly to that longitude. In connection with this exploration he made a track-survey of the northern arm of Grand Lake, which has a length of about twenty miles, and thence across the watershed, and down the chain of lakes and streams which leads in the same direction to Shabogamog Lake. A track-survey and a geological examination were made of this lake, which proved to be over thirty miles long. Mr. Cochrane next descended the river flowing from this Shabogamog Lake for a distance of over ten miles, northwordly, where a series of rapids begins. It proved to be a large stream, fully equal to the Ottawa just below Grand Lake, and is apparently the head of the un-named river

* Report of Progress, Geol. Surv., 1872-73, pp. 112-135.

flowing into Hannah Bay, at the southern extremity of James' Bay. The height of land passes close to the northern extremity of Grand Lake, and soon after crossing it Mr. Cochrane found crystalline schists of the Huronian system, and further on they were met with here and there, alternating with Laurentian-like gneiss, as far as the outlet of Shabomagog Lake, beyond which the schists were continuous as far as he descended the river. There is little doubt these rocks form part of the Huronian belt, extending eastward from Abbittibbi Lake.

"On returning to Grand Lake, Mr. Cochrane, according to instructions, descended the Ottawa to Lake Temiscaming. The section of the river lying between Grand Lake and Lac des Quinze had been surveyed with the micrometer by Mr. Lindsay Russell, and it only remained for Mr. Cochrane to note the geological formations. The rocks along this division of the Ottawa proved to consist entirely of Laurentian gneiss. The Huronian schists, between Lac des Quinze and Lake Temiscaming were examined and reported on by the late Mr. McOuat, in 1872.

"Leaving Mr. Cochrane at Grand Lake to continue the explorations which have just been described, I proceeded up stream towards the source of the Ottawa. Grand Lake, the Ottawa River and the lakes upon its course as far as Barrier Lake, had been explored by Mr. Henry C. Symmes, P.L.S., in 1866, so that I only required to examine this section geologically, and throughout its whole extent the only rocks seen were gneiss.

"Above Barrier Lake, both a geological examination and a track-survey of the Ottawa were made to its source, which was found to be in a small lake at the head of the north-western and longest of the two branches into which it ultimately divides. This sheet of water, which is only about two miles long, had no name, and I called it Ottawa Lake, as an appropriate designation, and as following the almost universal rule which obtains in these regions by which the lake at the source of a river bears the same name as the river flowing from it. Laurentian gneiss continued to be the only rock observed all the way from Barrier Lake to Ottawa Lake.

"From Ottawa Lake I crossed the water-shed to Echaume Lake, one of the sources of the Gatineau River, and then descended that stream, which is constantly augmented by tributaries from either side as far as the river Désert, continuing to make both a track-survey and a geological examination the whole way. No rock but gneiss was met with in descending the Gatineau until reaching a portage about thirty miles below the Zigonse or principal north-east tributary of the river, where a white weathering coarsely crystalline light grey limestone made its appearance, and was afterwards traced, almost continuously,

down the river nearly to its mouth. This well characterized belt of limestone has evidently a great thickness. Thinner bands of a somewhat similar crystalline limestone were observed interstratifying gneisses, &c., in the lower part of the valley of the Désert. From this point I brought my canoe-men by stage to Ottawa, and thence sent them back to Lake Temiscaming *viâ* Mattawa."

The limestone above referred to by Dr. Bell was first noticed by Mr. J. Richardson in 1870, and is pretty fully described by him in the Report of Progress, Geol. Survey 1870-71, in which, on page 289, he says: "Without further examination it would be impossible to say whether these limestone which are so largely displayed along this portion of the Gatineau River form one or more bands. The thickness of this limestone in some parts cannot be short of five or six hundred feet and below the Big Eddy Portage may reach a thousand feet."

Dr. Bell further reports that while endeavoring to ascertain the nature, structure and geographical distribution of the rocks in the districts examined during the season, special attention was directed to the discovery of economic minerals:

"In this connection it may be mentioned that some days were devoted to an enquiry and examination into the alleged discovery of auriferous quartz veins in several places in the vicinity of Mattawa. The various openings where the discoveries were said to have been made were visited, and a number of specimens were collected. These have since been assayed by Mr. Hoffman, but without finding gold or silver in any of them.

"The glaciation of the fundamental rocks and other phenomena of the drift were studied, and many interesting facts noted, but these will be more appropriately recorded in the detailed report to be prepared. Numerous observations for latitude were made, which will be used to give greater accuracy to the maps of our track surveys. Notes were constantly kept in reference to commercial timber and to the distribution and the northern limits of the trees in the region visited. Considerable information was gathered on the natural history of the districts, especially with reference to food fishes; and collections of Coleoptera and Lepidoptera were made. The temperature of Lake Temagami and of other lakes was recorded three times a day by Mr. J. Fraser, a member of the party.

"Forty photographic views were taken to illustrate the various characteristic features of the scenery, points of geological interest and the general aspect of the country.

"As on all previous occasions, the Survey is again indebted to the officers of the Hudson Bay Company for their kind hospitality and assistance in promoting the work, and in this connection I may be

allowed to mention more particularly Chief Factor Colin Rankin, Mr. C. C. Farr, J. P., Mr. J. Mann, Mr. L. Christopherson and Mr. J. Turner.

Cost of season's exploration, $2,036.87.

Mr. F. D. Adams left Ottawa on the 13th July, and spent the following three months and a-half in exploring and mapping in detail those portions of the counties of Montcalm and Joliette, which are included in the north-west quarter sheet of the map known as the map of the Eastern Townships.

The area examined by Mr. Adams has an extent of about 1,200 square miles, and lies immediately to the north of that explored by him in 1885. He now states that:

"The great mass of anorthosite underlying Morin, Abercrombie, Wexford and several other townships in Montcalm and in the adjacent counties, and the southern and western boundaries of which have already been determined, was still further examined, and its southern and eastern boundaries carefully traced. In doing so the unexpected fact was ascertained that the so-called massive and stratified varieties of this rock are in reality only different portions of one and the same mass. A number of small outliers of anorthosite were found in the gneiss to the east of this main area, resembling those found before on its western and southern sides. Four bands of crystalline limestone were also found east of the Lac Ouarreau band and on the eastern side of the principal anorthosite area, some of which undoubtedly correspond to those found by Sir William Logan on its western side. As a result of this summer's work, I think it may be safely concluded that the rocks comprising the principal area of anorthosite above referred to, as well as most, if not all, of the smaller areas, are of eruptive origin.

"All localities, where minerals of economic importance were reported to occur, were visited and examined. These were for the most part deposits supposed to contain either gold or iron ore, many of which are associated with bands of pyritous rock near the contact of the anorthosite and gneiss. Several of them, now abandoned, had at one time been more or less extensively worked for gold. Specimens of these ores were collected, and it is proposed to assay them, in order to ascertain whether they really contain a sufficient amount of gold to warrant further efforts being made for their development. A large number of other specimens were also collected, some of which, it is hoped, may prove of economic importance, as well as of scientific interest.

"There still remains a large area to be examined within the limits of the map referred to, and until this is effected and the map can be

completed for publication, it is deemed desirable to defer the preparation of a detailed report on the geological structure of the district. A short report will, however, be prepared during this winter, dealing chiefly with the economic resources of those portions already examined, and which seem to be of more immediate practical importance.

Cost of season's exploration, $563.00.

Dr. R. W. Ells, with Mr. N. J. Giroux as assistant, was occupied during the past season in continuing to the north-east the final examination and mapping of the geological formations on the south side of the St. Lawrence, in a part of the area comprising the north-east quarter sheet of the map of the Eastern Townships, extending from the county of Megantic north-eastward to the county of L'Islet. This work was, as stated, a continuation of that of the previous season to the south, which is described in the summary report for 1886, and in greater detail in part J of the annual report recently issued. The first two months were devoted principally to an examination of the gold-bearing rocks of the Chaudière district, and later the rocks along the southern side of the St. Lawrence were re-examined from St. Nicholas towards Rivière du Loup, together with some of the islands below the Island of Orleans. The object of this was to ascertain, and to map more accurately than has been hitherto effected, the distribution and the relative positions of the Levis formation and of the so-called Lauzon and Sillery formations along the borders of the St. Lawrence, where the rocks, over considerable areas, were in 1869 assigned to the horizon of the Potsdam sandstone, while other large areas of precisely similar rocks were still included in one or other of the sub-divisions of the so-called Quebec group. The reconnaissance examination which I have, from time to time, carried out in all parts of the region since 1874, had made it evident that an entire revision of the work of 1869 and previous years was now required, and this was commenced by Dr. Ells in 1885, and has since been ably prosecuted by him. The observations of the past season must now be carefully studied, and another season's work in the area will be required before the actual distribution of the formations can be fully ascertained and finally mapped, and the geological structure reported on, as there is still a very large area, probably not less than 1,250 square miles, in the counties of Bellechasse, Montmagny and L'Islet, that has been but little, if at all, explored. Much of it is thickly wooded and difficult of access; but as it is on the line of strike of the mineral-bearing belt to the south-west, it is not impossible that in some parts of it there may be a recurrence either of the asbestos, the iron ore, or the cupriferous deposits of that belt. In any case it is very desirable that the whole area should now be fully

and exhaustively explored, and its geological structure worked out before the map of it is published. This, is hoped, may be accomplished next year. A number of outcrops of serpentine, which are confined to the area south-west of the Etchemin River, were examined, with a view to finding workable deposits of asbestos, but though at several of these small veins of asbestos were observed, the mineral does not appear to occur in sufficient quantity to be of economic importance, and the altered igneous rocks with which it is associated to the south-west, chiefly in what has been called the volcanic belt, seem to disappear after the valleys of the Chaudière and Etchemin rivers are crossed.

On mining in the district, Dr. Ells reports :—

"The output of asbestos at the mines of Coleraine and Thetford has largely increased during the past season, and preparations were being made to continue working during the winter. Several new mines have been opened at Thetford and near the Coleraine station which promise well.

"The Broughton Mine, situated on lot 14, range 7, Broughton, about half a mile west of the Quebec Central railway, is still being worked, though its present output is not very considerable. The asbestos at at this mine occurs in an irregular vein along the contact between the serpentine and the black Cambrian slates, and differs from that obtained at the other mines of this mineral in character of fibre, and in its being associated with soapstone. It is, in so far as yet ascertained, confined to but one vein of any importance. Three shafts have been sunk in the line of outcrop, and some very excellent asbestos has been extracted, more especially from the upper portion of the vein. Very good indications of asbestos were also observed on lots 27, 28 and 29, range A, Coleraine, near the Poudrier road, the property of Dr. James Reed. Though but little work had been done, a number of veins of asbestos were exposed at the surface, varying in thickness from half an inch to an inch and a half.

"The gold mines of the Chaudière have not yet been developed on a scale commensurate with their importance. During the past season three companies have been engaged in mining operations, viz., the St. Onge Co., on Slate Creek, at St. George, Beauce; Messrs. Coupal & McArthur, on Mill Creek, near St. Francis village, and Capt. Richards on the Cumberland Stream, a branch of the Famine River. On the DesPlantes River also, Mr. Horace Sewell has been engaged in prospecting, with the object of finding the old channel of that stream, and claims to have been successful in locating it, though no work has yet been done to test it as a source of gold. At St. Francis, Mr. Coupal states that he has found considerable 'coarse' gold.

"During the past summer the old copper mine at Harvey Hill has

again been opened up, under the management of Mr. Chas. Lionais, but at the time of my visit the operations were confined principally to repairing the shafts and buildings. This mine has already been fully described in the Geology of Canada, 1863, pp. 724, 728, and no further information need here be given concerning it.

"Work has again been resumed at the South Ham antimony mine. This property is mentioned in the Geology of Canada, 1863, p. 876, and later in the Report of Progress Geo. Survey 1881-82, p. 399. It has lately changed hands, and is now owned by Dr. James Reed, who, within the present year, 1887, has driven a tunnel from the lower part of the hill in which the mine is situated, a distance of 304 feet, which has struck the vein at the bottom of the 100 foot shaft, with which also the other workings of the mine are connected. The mineral bearing lode, cut by the tunnel, is reported by Dr. Reed to be seventy feet in width, all of which he says will pay for extraction. The object of the tunnel driven by Dr. Reed is to drain the workings and to facilitate the extraction of the ore. Dr. Reed has already taken out about twenty tons of ore, and intends carrying on the work during the winter. The great difficulty in the way at present is the lack of a market, a difficulty likewise experienced at the antimony mines of Nova Scotia and New Brunswick. According to the 'Mineral Resources of the United States, 1885,' the price of 50 per cent. ore was at that date $10 per ton, the amount of crude antimony and regulus imported into the United States for that year being 2,668,302 lbs., valued at $223,741, and of antimony ore 243,635 lbs., valued at $8,783.

"Attention has again been directed to the iron ore deposits of Leeds. These ores, referred to in the Geology of Canada, 1863, p. 677, were subsequently examined by the late Mr. Chas. Robb, M.E., and are also referred to in "Iron Ores of Canada, p. 205, Rep. Geol. Sur., 1873-74," by Dr. Harrington, who says: 'The strata have been exposed by stripping for a distance of forty yards in the direction of the strike, and sixteen yards across it. In the latter distance three tolerably regular beds of ore were seen, respectively six, four and three feet thick, and all dipping to the north-west at an angle of °50. The beds are separated by bands of chloritic slate, containing quartz and felspar. The ore is a fine-grained magnetite, more or less mixed with micaceous iron ore, and some specimens exhibit polarity in a marked manner.' Similar ores occur in the adjoining township of Inverness. The analysis of the Leeds ore, by Dr. Harrington, gave: metallic iron, 67.079; phos., ·206; sulphur, ·038. These ores are distant from the Quebec Central railway, at Robinson station, about ten miles, and from the Grand Trunk railway, at Bécancour station, from sixteen to eighteen miles.

"The field work was commenced on the 4th of June, and terminated on the 19th October—cost $1,449.33."

Professor Laflamme, who was engaged for a short time during the summer in re-examining the country, and in continuing the revision of the geological boundaries on the north side of the St. Lawrence above Quebec, furnishes the following report:—

"A detailed examination was made of the country between the St. Maurice and the Batiscan Rivers, especially that portion of it which lies to the north of the boundary of the Cambro-Silurian rocks. The rocks observed here, as everywhere else in this region, belong to the Laurentian gneiss, which occurs in all its varieties. I, however, observed also three important bands of crystalline limestone in the parish of St. Tite. One commences at the southern extremity of Lake Roberge and runs westward to Lake Claire where it terminates. It is a coarse-grained limestone and encloses many fragments of gneiss, occurring as angular blocks regularly distributed through the limestone. The exposure is abont five or six hundred feet wide, and about half a mile in length. The stone could, probably, only be utilized for burning into lime.

"The second band occurs about six miles to the south-east of the first. It is a fine-grained rose-colored limestone, susceptible of taking a fine polish, and consequently of being used as an ornamental marble. At the junction of the limestone and gneiss, there is a distinct appearance of bedding or alternating bands of limestone and of gneiss dipping south-easterly 75°. The exposure is about two acres in extent.

"The third band occurs about a mile to the south of the second, and the limestone closely resembles that of the Lake Roberge band, the crystals perhaps even larger. It likewise encloses many angular fragments of the surrounding rock. It could not be utilized as a marble.

All this northern country closely resembles the Saguenay district in the manner in which the deposits of clay "glaise," occur. These deposits are very irregular, and show much false bedding in most of the section made by the railway. There is no trace of quarternary fossils like those of the country in the vicinity of Quebec, and it seems that these deposits are all the result of the submergence of this part of the country by the fresh waters of the melting ice and snow of the glacial epoch. The country is generally fertile, but there is a larger number of extensive projections of Laurentian rocks, which interrupt the continuity of the clay deposits.

"East of Batiscan River the Laurentian rocks present the same general characters, as do also the arable lands. The general strike is north-east and south-west, and there is no trace of limestone bands in this region.

"I also made a further geological examination on the St. Anne River, but have nothing to add to what was stated last year.

"The Trenton limestones are very regular, with a scarcely discernable dip to south-southeast. About two miles above St. Anne's church they are covered by the Utica and Hudson River formations.

"In conclusion, I desire to draw attention to the work now being done in this part of the country in connection with the occurrence of natural gas.

"Already a number of wells have been bored, and though the result has not been what was at first anticipated, yet there is no reason why judiciously conducted researches should not some day be crowned with success. The discovery of natural gas in available quantity in the province of Quebec would be extremely valuable. We have no coal to work our minerals. Natural gas might replace it and give a fresh impulse to all our industries. Abundant sources of natural gas have been found in Ohio in the same formations, adding a certain degree of probability to the presence of gas in our Trenton and Utica formations.

"Cost of explorations, $400."

From the above it might, perhaps, be inferred that natural gas had not been discovered in these formations, and, therefore, it may be well to quote the following passage from chapter xvii, p. 527 of the Geology of Canada, 1863, from which it will be seen that both gas and petroleum have long been known to occur over wide areas in Canada from the vicinity of Quebec to the Manitoulin Islands, and it has also long been known to occur in the Gaspé Peninsula:—

"The light carburetted hydrogen or marsh gas, which is so often a product of the transformation of organic matter at ordinary temperatures, is abundant in the palæozoic rocks of Canada and issues from many mineral springs. Those of Caledonia, Varennes and Caxton, in the Lower Silurian series, give off great volumes of this gas, which keep the waters in constant agitation. Many other less important instances of the same kind might be mentioned, while in the higher strata of western Canada this gas is still more abundant, as at the well known burning spring near Niagara Falls and in the region of the oil wells. In boring these, reservoirs of it are frequently penetrated from which the gas is liberated with explosive violence. In nearly all the oil wells there is a greater or less disengagement of inflammable gas; so that it would appear that the strata almost everywhere in that region hold, in a condensed state, portions of light carburetted hydrogen, which is discharged wherever a natural fissure or an artificial boring furnishes a vent.

"It was further stated *Op. cit.* p. 788: 'The possibility of its occur-

rence in available quantities in some parts of the Trenton formation should not be lost sight of.'

"During the past three or four years, attention has again been directed to this question, chiefly through the great developments that have during that period been made in Pennsylvania, Ohio and other states, and several wells have been sunk in the province of Quebec with a view to develop the indications of petroleum and natural gas, which, as already stated, were long ago pointed by the Geological Survey. The most important of these trials was made in the summer of 1885, and it seems desirable to quote here the detailed description of it by Mr. Obalski, as published, pp. 116-117, Report of the Commissioner of Crown Lands, Quebec, 1885."

GAS WELL NEAR ST. GRÉGOIRE, COUNTY OF NICOLET.

"These borings were effected on Mr. Hilaire Trudel's land (No. 501 of the Cadastre) at the south-east end of the concession of Bonsejour (Seigniory Roquetaillade). The following table gives the depths reached and the nature of the rock encountered :—

	On the surface, 31st July, 1885, 1 foot of earth, good cultivatable soil, flow of odorless gas.
From 1 to 48 feet.	47 feet of blue loam, with thin layers of sand.
From 48 to 53 feet.	5 feet of white sand, with abundant emanations of odorless gas.
From 53 to 68 feet.	15 feet of heavy gravel, composed of pebbles of granite, sandstone, calcareous rock, &c., with abundant emanations of odorless gas and water.
From 68 to 75 feet.	7 feet of black sand, very dense, hard to penetrate; water, but no gas.
From 75 to 155 feet.	80 feet of solid rock, sandstone, somewhat calcareous, soft enough to be cut with a knife; oily oozings.
From 155 to 215 feet.	60 feet of same rock, but harder and of a finer grain.
From 215 to 290 feet.	70 feet of red shale, wrongly called by the miners "soapstone."
From 290 to 300 feet.	10 feet of same rock, lighter color.
From 300 to 316 feet.	16 feet of same rock, nearly black.
From 316 to 370 feet.	54 feet of blackish brown schist, not hard; abundant and sudden flow of gas, having a strong smell of kerosene.
From 370 to 475 feet.	105 feet of red shale; more abundant emanation of gas.
From 475 to 525 feet.	50 feet of red schist, somewhat greyish.
From 525 to 580 feet.	55 feet of red schist, softer.
From 580 to 640 feet.	60 feet, another flow of gas, more violent, throwing mud and stones from the bottom to a height of 60 feet in the air, and preventing work. This gas affects the sight and the lungs of the workmen; continuation of red shale.

From 640 to 660 feet.	20 feet of impure calcareous rock, apparently containing magnesia. Another vein of gas of the same nature.
From 660 to 720 feet.	60 feet of calcareous rock.
From 720 to 820 feet.	100 feet of oily calcareous rock.
From 820 to 860 feet.	40 feet of black schist, soft to the touch. New vein of the same gas.
From 860 to 1,115 ft.	225 feet of compact black schist.
1,115 feet.	Work suspended. The gas continues to flow with such force that it is impossible to close the orifice, so two pipes of ½-inch diameter are fitted to the main one.

"This boring has evidently passed through the Medina shales and sandstones which appear to be here 565 feet thick* and the remainder of the boring, 540 feet. seems to be in the Hudson River rocks. Below these the Utica, and the Trenton would be found, and as it is at the junction of the latter that the main gas and petroleum occurs in north-western Ohio it seems very desirable that the St. Grégoire boring should be continued till it reaches the Trenton limestone. The Ohio section shows the Medina only 80 feet thick with 305 feet of Clinton and Niagara on top, and at the base of the Medina there is a heavy flow of gas, as is the case at 640 feet deep, the base of the Medina, at St. Grégoire. Below this in Ohio are 430 feet of Hudson River strata and 275 feet of Utica shale, at the base of which, or a few feet lower in the Trenton limestone are, as above stated, the great petroleum and gas reservoirs.

"An all-important consideration in connection with the probable occurrence of these reservoirs is that of the geological structure of the district, and while for reasons in connection with this I have never had any faith in their occurrence on the north side of the St. Lawrence, I consider that the probability of such reservoirs existing on the south side, in the country between Lake St. Peter and St. Hyacinthe, is very great, especially along, or in proximity to, the central part of the line indicated by Sir W. E. Logan as the course of the Deschambault anticlinal.—Geol. of Canada, 1863, pp. 152, 205 and 272.

"At St. Grégoire, 550 feet of Hudson River strata have been penetrated. Between the Island of Orleans and the north shore of the St. Lawrence, Sir W. E. Logan estimated the thickness of the Hudson and Utica at 2,000 and 300 feet respectively. Supposing them to be equally thick at St. Grégoire the boring would have to be continued 1,700 feet before reaching the Trenton limestone. A little north of St. Hillaire, on the Grand Trunk railway, however, the Trenton limestone would probably be reached at a much less depth, as the axis of the anticlinal gradually rises in that direction, and the upper measures of the Hudson River and the Medina are absent.

* The thickness of the Medina formation at the west end of Lake Ontario is (Geol. of Canada, 1863, p. 312) as 614 feet.

"In any case the question may certainly be regarded as one of great importance in comparison with the small amount of money which would be required to thoroughly test it.

"As regards the question of manufacturing industries in connection with natural gas as a fuel, however, I may quote the following remarks by Professor Lesley.†

"The facts in reference to natural gas wells, briefly given above, point to the conclusion that gas wells have their regular life, and that the quantity of gas is a limited amount. If a single well is down and yielding gas, the pressure will remain constant and the supply regular for many years, but as soon as new wells go down in the immediate vicinity the total gas supply is sooner or later exhausted and all the wells cease yielding gas.

"The necessary result of this would be that natural gas as a fuel for iron puddling and other uses must be confined to the position of an economical adjunct to other fuels. That is, for works in all other respects well situated for successful iron working, with a cheap coal supply, immediately available upon a temporary or permanent ceasing of the gas supply, this natural gas can be brought in as a fuel and used with heavy saving of cost. But it is highly improbable that it could ever pay to locate works on a gas supply in a position where without the gas the works could not be successfully run. It is therefore as an economical adjunct, and not as a main source of supply that this gas must be regarded."

In New Bruswick, work was continued during the past summer by Professor Bailey and Mr. McInnes, assisted by Mr. J. W. Bailey. Professor Bailey's attention was first directed to the examination of the country on the upper waters of the St. John River, with a view to determine the limits of the Silurian System in that direction and its relations to the so-called Quebec group supposed to underlie and flank it on the northern side. With this object in view, an attempt was made to ascend the valley of the St. John to the north-west branch, where only a short interval separates the St. John waters from those of the Etchemin River flowing to the St. Lawrence: owing, however, to the dry season and the consequent low state of the water, it was found impossible to ascend further than the Seven Islands, and even this point was reached with difficulty, while the ascent of the Big Black and Little Black Rivers had to be abandoned.

Having obtained as much information as possible regarding the Silurian rocks in northern New Brunswick and in the adjacent portions of the province of Quebec and the State of Maine, it was considered advisable as a preliminary to the examination of the older rocks,

† Report L. 2nd, Geol. Survey of Pennsylvania, p. 171.

hitherto known as the Quebec group, to obtain somewhat greater intimacy with the latter in the localities where they were first observed and where their typical features can be best studied.

For this purpose Professor Bailey visited Rimouski and Bic, and then carried his examination inland, till, at the village of St. Blondin, he not only found the western edge of the Silurian rocks, but that there, and in the adjacent Bois Brulé Mountains, the beds were highly fossiliferous, and from them considerable collections were made. He then visited Quebec, where Dr. Ells was engaged in similar work, and with him made a boat trip down the St. Lawrence, thus acquiring a familiarity with the rocks of the so-called Quebec group which would not otherwise have been possible, and which will greatly facilitate his further study of the similar formations in New Brunswick.

During the latter part of the season, the cuttings recently made in constructing the Témiscouata railway were carefully examined, as was also the country in the vicinity of Témiscouata Lake. In the latter examination Professor Bailey was accompanied by Mr. Ami, who made a thorough exploration of the fossiliferous strata of Mount Wissick, Point aux Trembles and Lake Tuladie, and secured a number of interesting fossils, which must be critically examined before any precise correlation of the strata in which they occur can be made. The district was examined in 1849 by Sir W. E. Logan, and is described in the Geology of Canada, 1863, Chap. XVI, pp. 420-423, under the heading "Gaspé Series."

The attention of Mr. McInnes was devoted chiefly to making measurements and securing other data required for the completion of the quarter-sheet map, 17 N.E. of the New Brunswick series, on a scale of four miles to one inch. His observations extended also into the area, which will be included in the adjoining quarter sheet, to the north. A micrometer survey was made of the north side of the St. John River from Edmundston to the mouth of the St. Francis, and of the St. Francis River and lakes, in all about 100 miles. The region to the east of the inter-provincial boundary, in Restigouche county, was examined by ascending the Green River and crossing by a portage of about seven miles to the Quatawamkedgewick, and thence by the Restigouche and Grand Rivers to the St. John. The whole of this region was found to be occupied by strata of Silurian age. Large areas of good land are yet available for settlement in the valleys of these streams, along which there are many fine alluvial flats, with good soil on the uplands. About 250 miles of roads and streams, of which surveys were available, were traversed and examined during the season.

Mr. McInnes further reports that game, owing to the protection afforded it by law, is still fairly abundant in this region; that moose

and cariboo are numerous, and that red deer have latterly been coming in in considerable numbers from the adjoining state of Maine.

During the first part of the season Mr. J. W. Bailey was occupied in making an examination of the St. Francis River and its tributaries from their sources along the line of the Temiscouata Portage road to the junction of the same stream with the St. John. He also made a detailed examination of Temiscouata, Boundary, and other lakes as to depth, physical peculiarities, &c. Subsequently he accompanied and assisted Professor Bailey during the remainder of the season.

Mr. McInnes left Ottawa for field work on the 5th of July, and returned on the 11th October. Professor Bailey was in the field from 12th July to the 21st September.

Cost of season's explorations $1,024.60.

The geological features of this region will form the subject of a detailed report and map, which will be prepared when the observations have been studied, the fossils determined and the measurements plotted. Another season's work in the field will, however, probably be desirable before the report and map referred to are published.

Mr. R. Chalmers left Ottawa on the 12th of May for New Brunswick to continue the examination and mapping of the surface deposits within the area embraced in the quarter-sheet maps Nos. 1 S.E. and 1 S.W. bordering the Bay of Fundy. In 1885 the area embraced in the quarter sheet maps 3 S.E. and 3 S.W. was surveyed and the report and accompanying maps are published as Part M. of the Annual Report, 1886. During the season of 1886 Mr. Chalmers made a detailed examination of the surface deposits in north-eastern New Brunswick, in the area covered by the quarter-sheet maps 2 N.W. and 6 S.E. These latter, with the report referring to them, are now waiting to be printed. Each of these quarter-sheet maps covers an area of 3,456 square miles. Mr. Chalmers has, therefore, now examined, making allowance for water areas, about 20,000 square miles.

During the past season the work in the field was continued to the 14th December. The cost being $749.42.

Mr. Chalmers states "that the mapping of the different superficial formations was carried out in greater detail this season than had hitherto been attempted, the more settled condition of the country affording better facilities for doing so. All the important mountains and hill features, as well as the forest covered tracts, will be delineated on the map as accurately as time and circumstances permit. The representations of the hills and ridges in western Charlotte seemed to be absolutely necessary to exhibit the character of the surface deposits. In the vicinity of St. Stephen and eastward these ridges were found

to be capped with boulder-clay, while the valleys between them contain stratified materials.

"Observations with the aneroid barometer were regularly taken, based upon those of the meteorological stations at St. John and St. Andrew's, so that the heights in nearly every part of the area can be shown.

"The general character of the soil within the area under consideration is unfavorable to the successful prosecution of agriculture. Nevertheless, along the river valleys, and more especially in western Charlotte, there are excellent, well-cultivated farms. The land is good enough anywhere when once cleared of boulders; but owing to their abundance, the labor attending this is simply immense. At St. Andrew's there is a fine tract of land upon the Lower Carboniferous sandstones."

The maps and a full report will be prepared during the winter.

The explorations and surveys in Nova Scotia were conducted during the past summer, as heretofore, under the supervision of Mr. H. Fletcher, who left Ottawa for the field with his associates, Mr. E. R. Faribault, Mr. J. A. Robert and Mr. McMillan, on the 5th July. Mr. Fletcher's attention was devoted to the survey and examination, in which he was assisted by Mr. Robert, of that portion of Pictou county which lies between West River and the country that is described in Part B of the Annual Report for 1886, recently published. Mr. Fletcher reports having secured the services of Mr. Donald Fraser, of Springville, to trace the outcrops of the iron ores of the East River, and to describe the various workings on them.

Besides coal and iron ore, there are, within the area examined by Mr. Fletcher, workable deposits of gypsum, limestone, freestone, sand, brick clay and fire-clay. There is also a small deposit of bog-manganese in a brook at Glengarry.

The coal mines were not re-examined, but Mr. Fletcher states that "some alterations and some additions are now required in the map made by Sir W. E. Logan and Mr. Hartley, and published with the Report of Progress, Geological Survey, 1866-69.

"The iron ores of Pictou county, though not yet developed, must be regarded as next to the coal in economic importance. They are found at West River, Glengarry, Gairloch, Lorne, Bridgeville, Blanchard, Sutherland's and French Rivers, within a radius of seven miles and a half, and consist of limonite, red hematite, specular, spathic and bog ore, in such abundance, variety and purity as to astonish all visitors. The ores of the East River and Blanchard were worked sixty years ago, in a small way, by the General Mining Association. Since then

much money has been expended to develop the mineral resources of the district. It presents greater facilities for manufacturing iron profitably than are to be found in any other part of the Dominion, and it offers a field in which the investment of capital, by a company having enterprise and skill, would almost certainly result in the establishment of extensive and remunerative mining and smelting works, for the production of nearly all the grades of iron that are now imported. Pictou county is as favorably situated as are the best ore producing districts of Pennsylvania. There is a large market in the Dominion, as is shown by the value—nearly fifteen million dollars in 1886—of the iron and steel in various forms annually imported, much of which might be made in the country, labor being plentiful and cheap.

"The iron ores are in veins and in beds, varying in thickness from mere threads to one hundred feet. They crop out on hills and in bluffs, and the mines could be worked and drained by an adit to a depth, in most cases, of 200 to 300 feet, so that for some time to come neither pumping nor hoisting machinery would be required.

"The limonite, which yields 65 per cent. of metallic iron, is associated with manganese in quantity, thus strongly resembling the limonites that are brought to England from Spain to be used in the manufacture of spiegeleisen, manganeisen and steel. The percentage of iron in the other ores is variable, but all are of workable richness. The Pictou coal is free from sulphur and yields a firm, excellent coke. Limestone for flux is in close proximity and can be quarried cheaply in any required quantity."

A short and easily constructed branch railway would connect all the mines and the works with the Intercolonial main line, which now passes the coal mines, to an excellent shipping port on Pictou Harbor.

Cost of season's exploration $1,500.

Mineral Statistics.

Mr. Coste, Minining Engineer to the Geological Survey, has been engaged during the past year in collecting the material for, and in preparing a statistical report on the exports and imports and on the production of minerals in Canada in 1886, and, when the information was available, for some previous years also. This report, covering 85 pages, forms Part S of the Annual Report of the Geological Survey, Vol. II, new series 1886. It is also published separately and sold for twenty-five cents.

The articles relating to salt and silver were prepared by Mr. E. D. Ingall, Mining Geologist of this Branch.

Mr. Coste was ably assisted throughout by Mr. H. P. Brumell. He was further greatly aided, and the work was much lightened and expedited by the readiness evinced in all quarters to send in returns and answer enquiries, while but for the information afforded by the Department of Mines in British Columbia and by Mr. Gilpin, Chief Inspector of Mines in Nova Scotia, it would have been impossible to have completed the returns for those provinces.

Mr. Coste states that "about 2,000 forms and 400 letters were sent and 665 forms and 185 letters were returned. Plans of twenty different mines were secured and copied."

With a view to prepare for 1887 a more detailed and complete report on the mining resources and industries of the country than that now presented, the following places were visited during the summer by Mr. Coste in order to make personal examinations and enquiries :—

Port Arthur, Sudbury, Bristol Mine and places on the Kingston and Pembroke railway, Perth, Capelton and Montreal.

During these visits Mr. Coste observed "that in several districts the mining operations were being pushed with more vigor and success than during the previous year, especially in the Port Arthur silver district, along the Kingston and Pembroke railway line, at the Bristol iron mine, in the phosphate districts and at the Capelton copper mines. A wonderfully rich ore body was discovered in March of this year at the Beaver silver mine and in July was exposed in four different levels. Ninety to 100 tons of selected ore had been secured, which gave an average of $1,500 to the ton; 1,400 tons of rock, averaging by assay $40 per ton, had been treated in the mill, and had been reduced to about fifty tons of concentrates, averaging by assay $1,000 per ton. On one day in July assays of the mill rock gave $85 and the concentrates $2,300 per ton.

In the district along the Kingston and Pembroke railway and at the Bristol iron Mines, Mr. Coste observed a marked "renewal of activity in the working of the iron mines by two strong companies."

"Some of the Canadian ores, it is true, contain a high percentage of sulphur, but so do the similar iron ores of New Jersey, in some instances as much as $\frac{3}{4}$ per cent., and yet these ores are mined in large quantity. In 1880, there were 112 mines being worked in New Jersey, which produced 739,369 tons of ore. An analysis of the average ore of the Sulphur Hill mine gave 2·527 per cent. of sulphur. This ore was used in the company's furnace at Chester, N. J., but was first roasted in Taylor's patent gas kilns, and it is stated that in a sample taken from 100 tons of the roasted ore only 0·786 per cent. of sulphur could be detected. *

* Tenth Census of the United States. Vol. XV, pp. 145-147.

These facts are given by Mr. Coste to show that there is no apparent reason why the same treatment could not be successfully applied to the sulphurous Canadian ores, and he states that the experiment is now being tried by the enterprising Ottawa capitalists who are working the Bristol mine, and who last summer erected two large Taylor-Langdon gas kilns to roast their ore before shipment. Should this prove successful it will probably lead to the further development of a number of large deposits of iron ore that have hitherto been neglected.

At the Capelton copper and sulphur mines some extensive new works were in progress both at the mines and near the railway station. At the latter, large new sulphuric acid works, nearly completed, and fitted with the best improvements, were being built by the present owners of the Albert, Hartford and Capel mines, Messrs. G. H. Nichols & Co., of New York. At the mine, also, extensive preparations for working on a larger scale were being made. These included the erection of a large crushing and concentrating plant, two new boilers, a pumping station three-quarters of a mile from the mine, a powerful hoisting engine, two air compressors and two shaft houses with corresponding well constructed skip roads. The old Albert, or present No. 1 shaft will also be repaired. It is now about 810 feet deep, and the vein is, on the whole, stronger in depth than it was nearer the surface. This is also the case in the Crown mine, which is further west on the same vein, and continues in active operation, the shaft having now reached a depth of more than 1,500 feet. Nearly 44,000 tons of ore were exported from these two mines (Albert and Crown) to the United States in 1886. The ore is an argentiferous iron and copper pyrites, very similar to, but holding a larger percentage of both copper and silver than that of the celebrated Huelva district in Spain, whence 550,000 tons were exported ta England in 1886, valued at a little more than one million sterling. *

The cupriferous pyrites of the Eastern Townships contains as much sulphur as the Spanish pyrites and is, as stated, richer in copper and silver. If it could be introduced into England at the same price, about ten dollars per ton, there seems no reason why it might not compete successfully with the Spanish ores, and thus lead to the development of other valuable mines in the Eastern Townships.

In the phosphate mining industry Mr. Coste states "there is a renewal of activity in the Ontario district, where two promising properties are being worked by Capt. Boyd Smith, and by the Anglo-Canadian Company. In Quebec, Ottawa county, the mines continue to be actively worked and the production this year will probably be greater than in 1886." The introduction of Canadian phosphate in the

* Mining Statistics of the United Kingdom, 1886.

United States is likely to become an important feature of the industry, and to afford a large and profitable market.

Some hesitation and distrust is still noticed among many of the phosphate miners. This arises from the often irregular nature of the deposits, and from an idea, at one time somewhat prevalent, that most of the deposits were mere surface pockets. In this respect, however, there is no reason for supposing that the deposits of phosphate differ from those of iron ore or of any of the other associated minerals, and thus, while some of the deposits may be quickly exhausted, others will be permanent to the greatest depth to which mining operations can be profitably carried.

During the summer Mr. Brumell was requested by Mr. Coste to visit localities in the counties of Esssex, Lambton and Brant, in Ontario. He also spent five weeks in New Brunswick, in King's, Queen's, Westmoreland, Charlotte, York, Sunbury and Northumberland counties.

Early in October he was sent to examine into a reported discovery of coal at Campbellford in Ontario. The report, as was well known it must, turned out to be unfounded, the country there being all occupied by the Trenton limestone formation.

On the 13th of October Mr. Brumell went to Lake Temiscaming, but owing to the steamer on the lake being disabled was unable to effect anything or to visit the mines.

Field expenses of Messrs Coste & Brumell $1,088.40.

Chemistry and Mineralogy.

The report furnished by Mr. Hoffmann on the work carried out in the chemical laboratory includes that in connection with the mineralogical section of the museum, to the arrangement of which much time and care has been devoted by Mr. Hoffmann, and, as a number of new specimens has been added to the collections, considerable extension and re-arrangement of the cases has been necessary.

Mr. Hoffmann reports as follows :—

"The work carried out in the chemical laboratory during the past year may be said to have an almost exclusive economic character. It included :—

"I.—Analyses of numerous specimens of lignites, lignitic coals and coals from the North-West Territory and British Columbia. Of the coals examined from the last named province, three were from seams of considerable thickness, and proved to be of very superior quality.

"II.—Analyses of iron and copper ores.

"III.—Analyses of mineral waters.

"IV.—Gold and silver assays. The number of these assays made in the laboratory during the period above specified amounted to one hundred and forty-eight, and exceeds that of any previous year.

"V.—Miscellaneous examinations, embracing chromic iron ore, clay, &c., &c.

"In the last summary report of this section mention was omitted of the following additions to the list of minerals previously known to occur in Canada, viz., cookeite, uraninite, monazite and smaltite. They have, however, been fully referred to in Part T, Annual Report, 1886. The second mentioned, uraninite or pitch-blende, constitutes the principal ore of uranium, and is of economic importance, being employed in chemical operations, for painting on porcelain, and glass staining.

"The number of mineral specimens received for examination amounted to six hundred and ninety-eight, as compared with five hundred and forty-six for 1886, and three hundred and thirty-nine for 1885. A large proportion of these were brought by visitors desirous of obtaining information in regard to their economic value, and this was in most instances communicated in the course of a personal interview. In many cases, however, a more than cursory examination was called for, and the results were subsequently communicated by letter. Notwithstanding that correspondence has been, as far as possible, limited to the writing of only such letters as were absolutely necessary for the conveying of information in regard to the results of examination, analysis, assay, or economic value of mineral specimens, it shows a marked increase over that of preceding years. Altogether the time devoted to visitors and correspondence has been very considerable. The number of letters written amount to two hundred and seventy-seven, as compared with one hundred and seventy in 1885.

"The mineral specimens collected by Dr. G. M. Dawson in the Upper Yukon district are under examination, and the two mineral waters from Harrison Springs, B.C., collected by yourself will now shortly be submitted to analysis.

"Mr. F. D. Adams has, (with the exception of about three months and a half during the summer, when he was engaged in field work in the counties of Montcalm and Joliette, in continuation of work commenced in the season of 1885) in the capacity of assistant chemist, rendered excellent service, amongst other work conducted by him being that of the analysis of the water of one of the principal thermal springs at Banff.

"Mr. E. B. Kenrick worked faithfully and diligently as junior assistant chemist up to the end of August, when he left to accept a professorship at St. John's College, Winnipeg. The position occupied by him has since been filled by Mr. R. A. A. Johnston, an earnest worker.

"In the mineralogical section of the museum some of the specimens have been replaced by better ones of the same kind, and one hundred and twenty-six new ones have been added. These include the following presentations:

Allan, W. A., Ottawa:—
Crystal of apatite from the Emerald mine, township of Buckingham, Ottawa county, Q. This crystal weighs five hundred and fifty pounds, and has a circumference of seventy-two and a half inches. It is supposed to be the largest crystal ever found in any country.
Muscovite, with inclusions of garnet, from the Villeneuve mica mine, Villeneuve, Ottawa county, Q.
Native silver from mining location R. 238, north of Atik Lake, west of White Fish Lake, Thunder Bay, Lake Superior, Ont.

Chisholm, Duncan, Salt Springs, N. S.:—
Brick-clay and bricks from Salt Springs, Antigonish county, N. S.

Copeland, J. S., Merigonish, N. S.:—
Infusorial earth from Merigonish, Pictou county, N. S.

Daly, Thomas:
Phlogopite, from the township of Portland, Ottawa county, Q.

Egan, H. L., Ottawa:—
Magnetite, from the township of Litchfield, Pontiac county, Que.

Haycock, E. B., Ottawa:—
Uraninite, from the township of Villeneuve, Ottawa county, Que.
Monazite, from the township of Villeneuve, Ottawa county, Que.

Hanks, Prof. H. G., 543 Clay street, San Francisco, Cal. U.S.
A fine specimen of the new anhydrous sulpho-carbonate of sodium, "hanksite"; also well-crystallized specimens of glauberite.

Keefer, T. A., Port Arthur, Ont.:—
Zinc blende, from the Zenith zinc mine, north shore of Lake Superior, Ont.

Lemieux, Joseph, Ottawa:—
Hematite, from Iron Island, Lake Nipissing, Ont.

McCool, James, Mattawa, District of Nipissing, Ont.:
Apatite, from the township of Ferries, district of Nipissing, Ont.

McDonald, R., & Sons, Arnprior, Ont.:
Polished column and base of Arnprior marble, the stone having

been taken from their quarry in the township of McNab, Renfrew county, Ont.

Mackenzie, Alexander, Montreal, Que.
Gold-bearing rock, from the Crow's Nest mine, Guysborough county, N.S.

McLaurin, J. Templeton, Ottawa county, Que.:—
Phlogopite, from the township of Templeton, Ottawa county, Que.

McNeely, J. L. Carleton Place, Ont.:—
Hematite, from the township of Beckwith, Lanark county, Ont.
Copper pyrites, from the township of Beckwith, Lanark county, Ont.

Moore, Isaac, Ottawa:—
Copper pyrites, from the south-east side of Straight Lake, district of Algoma, Ont.

Murphy, W. H., Ottawa:—
Zinc-blende, from the township of Calumet, Pontiac county, Que.

Poole, H. S., Stellarton, N.S.:—
Carboniferous conglomerate carrying native gold, from Gay's River, Colchester, N.S.
Altered bitumen, from the *falls measures* immediately overlying the Acadia seam at Westville, Pictou county, N.S.
Anglesite, from the Big Dome mine, Arizona.

Shea, Dennis, Bryson, Pontiac county, Que.:—
Zinc-blende, from the township of Calumet, Pontiac county, Que.

Toronto Stone Company, Toronto:—
A dressed cube of the dolomite, from Pelée Island, Lake Erie, Ont.

Van Horne, W. C., V. P. Canadian Pacific Railway. Montreal:—
Copper pyrites, from Sudbury, district of Nipissing, Ont.

Wild, General E. A.. Port Arthur, Ont.:—
Silver glance, from the Rabbit Mountain mine, Thunder Bay, Lake Superior, Ont.

Wright, G. B., Victoria, B.C.:—
Silver ore from four different claims, Illicillewaet, Selkirk Range, B.C.

"Mr. R. L. Broadbent was, for the space of eight months, engaged in the prosecution of the work of permanent labelling of specimens in the mineral collection, re-adjusting the contents of some of the cases, and the maintaining of the same in an orderly condition. During the remaining months he was occupied in writing labels, under the direction of Mr. Whiteaves, for the biological section of the museum.

Mr. C. W. Willimott has labelled and catalogued a large number of the specimens which are exhibited in the yard of the museum. These specimens consist, in part, of such as cannot, by reason of their size or nature, be accommodated in the museum, and of others, such as building stones, &c., upon which it is desired to ascertain the action of atmospheric influences. He has also been occupied in making up mineral and rock collections for various educational institutions, &c.

"Collections of this description have been forwarded to:—

	Specimens.
Depart. de Olras Publicas Republica Argentina, for exchange..	119
James Edmunds, London, England	42
St. Joseph Philosophical and Theological Seminary	105
Halifax Teachers Class and Halifax Academy	105
Professor J. G. Bonney, London, England	41
Captain Douglas	4
Canadian Pacific Railway (for exhibition at the Liverpool Exhibition)	75
Professor H. A. Ward, of Rochester, N.Y. (in exchange for specimens required for the museum)	81
	533

"Collections for the following will be ready in a few days:—

	Specimens.
J. C. Tremblay, Chicoutimi	115
High School Board, Aylmer	115
University of St. Joseph, Memramcook, N.B	115
Christian Brothers training school, Clonmel, Ireland	115
St. John's College, Winnipeg	115
Canadian Institute, Toronto	115
	1,223

"Collections for the following have yet to be made up:—

W. Smith, Land and Works Department, B.C.
Royal Military College, Kingston, Ont.
College Bourget, Rigaud, P.Q.

"In the course of the summer, Mr. Willimott visited the townships of North Burgess, Ramsay, Darling and Ross in Ontario, and Oxford, Chatham, Grenville, Villeneuve, Wakefield, and Hull, in the Province of Quebec, for the purpose of procuring certain mineral specimens required for the making up of collections for educational purposes. Whilst so engaged, he collected many specimens superior to those already in the museum collection, which they will replace, and in addition some other highly interesting ones, such as tourmaline in various stages of alteration, a mineral which may prove to be lepidolite, as also specimens of the monazite and uraninite, of which mention was made at the commencement of this report."

PALÆONTOLOGY AND ZOOLOGY.

In this division Mr. Whiteaves reports as follows:—"The illustrated synopsis of the fossils of the Hamilton Formation of Ontario, with descriptions of some new species, to which reference was made in the Summary Report of last year, has been published and distributed. The fossils, collected by Dr. G. M. Dawson in 1885 from the Mesozoic rocks of the northern part of Vancouver Island and adjacent coasts, have been studied, and a critical list of the species, with descriptions of such as are believed to be new, has been prepared and published as an appendix to Dr. Dawson's report on the geology of that district. An interesting series of fossils, collected by Mr. J. B. Tyrrell in 1885 and 1886 from the Cretaceous and Larimie deposits of the valleys of the Saskatchewan and its tributaries, has also been studied, and a similar list of species, with descriptions of several new forms, has been printed as an appendix to Mr. Tyrrell's report on Northern Alberta. A paper, descriptive of the whole of the fossils at present in the Museum of the Survey from the Triassic rocks of British Columbia, has been written during the year, but its publication has been deferred in consequence of the recent receipt from Mr. McConnell of some additional species collected by him, during the summer from deposits on the Liard River. These are evidently of Triassic age, a description of these species being deemed essential to the completeness of this presentation of the subject. The generic and specific affinities of these fossils from the Liard River, however, have been for the most part ascertained, as have those also of a small but remarkable assemblage of species recently collected by Dr. Dawson from the Cretaceous rocks of the Lewis River, a tributary of the Yukon. A preliminary examination has been made of a series of Cretaceous and other fossils obtained during the year by Mr. Tyrrell from the Duck and Riding Mountains in northern Manitoba.

"Considerable alterations and improvements have been made in the upper flat of the museum. The more important of these consist of the construction of six large and new upright wall cases, three for the reception of fossils, two for recent shells, and one for birds. One of these new wall cases is now filled with the remains of vertebrata from the Post Tertiary and Tertiary deposits of Canada, which have been skillfully re arranged by Mr. T. C. Weston. To this series an important addition has been made during the year in the shape of a lower jaw, with several vertebræ, ribs and limb bones of a *Mastodon*, which was discovered some years ago in a peat bog near Woodstock, Ont. In two of the other new wall cases the larger fossils of the Carboniferous and Permo-Carboniferous rocks of the Lower Provinces are now displayed to much better advantage than heretofore, these specimens also having been judiciously re-arranged by Mr. Weston. Two others have been devoted to the exhibition of a number of recent shells, of large and comparatively large size, many of which have been recently acquired by exchange. The whole of the shells in these new cases, and in another of similar size, have been neatly labelled by Mr. R. Broadbent, under Mr. Whiteaves' directions, the number of labels required for this purpose being 377. Mr. Broadbent, who has worked in this department for four months, has also labelled each specimen in the extensive series of recent mollusca from the Pacific coast of Canada now in the museum, so that the duplicates can be more readily distributed to educational institutions, and has placed upon exhibition in the cases a number of additional specimens. The last of the five new cases now contains 112 specimens of Canadian birds belonging to the family Oscinæ, very few of which had previously been exhibited.

"On the 31st of December, 1886, there were 44 mounted specimens of Canadian mammals and 142 of Canadian birds on exhibition in the museum. On the 23rd of December, 1887, the number of mounted specimens on exhibition was, mammals, 82 (including a fine example of a puma, shot in August last near Victoria, Vancouver Island); and birds, 352; many of which have been set up by Mr. Herring during the year. To most of these specimens a provisional label has been attached.

"The number of letters written is a little over 200; and for rather more than three months, in the absence of the Director on field work, the duties of Acting Director, as on several former occasions, have devolved on Mr. Whiteaves.

Mr. Weston reports that since the 30th of December, 1886, he has spent about three months in arranging, cataloguing and labelling several hundred ethnological specimens. He has also prepared about 150 microscopic sections of rocks from various formations. Between 13th June and 17th September, 56 days were devoted by him to field

work and to the examination of many fossil localities between Cape Rosier and Point Levis. In this exploration Mr. Weston was assisted by Mr. L. M. Lambe. A few days were subsequently spent in collecting fossils at Grimsby, Ont. Through the kindness of Mr. R. Thompson, of Grimsby, an unusually fine example of *Arthrophycus* (or *Harlania*) *Harlani* was secured for the museum. The rest of Mr. Weston's time has been occupied in museum work in the palæontological department.

Mr. H. M. Ami reports that during the earlier portion of the past year he was engaged in determining, classifying and labelling the large series of Silurian fossils collected by Mr. Weston in 1886, at various localities on the Arisaig shore, at Cape George and at Lochaber Lake, and in Antigonish county, N.S., from rocks which range in age from the Medina to the Lower Helderberg. He has also determined the Graptolites collected by Dr. Selwyn at Matane, and has helped Mr. Whiteaves in the examination of some Devonian fossils from Western Ontario. He has prepared systematic lists of labels, which have since been printed, for the fossils of the Hamilton Formation of Ontario enumerated in Mr. Whiteaves' "Contributions to Canadian Palæontology," Vol. 1, part 2, and for the graptolites of the Lévis Formation. Collections from the duplicates in the museum have been selected and labelled by him and sent to the following institutions or persons:—(1) To Laval University, Quebec, fossils; (2) to Mr. W. B. Clark, of Johns Hopkins University, Baltimore, fossils, in exchange for other specimens; and (3) to the Rev. Hector Currie, of Thedford, Ont., recent shells in exchange for Devonian fossils. Small collections, for special purposes, have also been forwarded for examination to Messrs. G. F. Matthew, E. O. Ulrich and C. D. Walcott. During the month of September and part of October, Mr. Ami was engaged in assisting Dr. Ells and Professor Bailey in their field explorations of various parts of the Province of Quebec, by collecting fossils with a view to ascertain the exact geological horizon of the rocks from which they were obtained. Since his return from the field he has examined the somewhat extensive collections of Natural History specimens of various kinds, which Mr. D. N. St. Cyr brought to Ottawa for identification, on behalf of the Quebec Government. These collections are intended to form the nucleus of a museum in connection with the Department of Instruction at Quebec, and consist of a large series of Canadian fossils, mostly from the Province of Quebec, and numerous species of marine, land and fresh water shells, with other invertebrata, from the gulf or valley of the St. Lawrence, exotic shells and the like. These collections have since been named, labelled and catalogued by Mr. Ami, under the supervision of Mr. Whiteaves, and duly forwarded to Quebec.

As in previous years, the whole of the drawings required for the illustration of palæontological reports have been carefully and skillfully prepared by Mr. L. M. Lambe.

The following collections have been received during the year from members of the staff or from gentlemen engaged in the work of the Survey:—

Dr. A. R. C. Selwyn:—

About 60 specimens of graptolites from the shales of the Lévis formation at Matane, Que.

Dr. R. Bell:—

About 250 specimens of fossils from the Silurian rocks of Lake Temiscaming.

One skin of a black hare from Paish ko-tchagami Lake.

About 120 specimens of coleoptera and fifty of lepidoptera from the Upper Ottawa region, extending from Temagami Lake and the Montreal River to the source of the Ottawa River, due north of Ottawa.

One Star-nosed Mole (*Condylura cristata*) from Ottawa.

One Jumping Mouse (*Zapus Hudsonicus*) from the Albany River.

Dr. G. M. Dawson:—

One Field Mouse (*Arvicola riparia*) from Finlayson Lake, Liard River, N.W.T.

One Red Squirel (*Sciurus Hudsonicus*) from the Yukon River at the confluence of the Lucas and Pelly.

One Northern Flying Squirrel (*Sciuropterus volucella*, var. *Hudsonicus*) from Chilkoot Inlet.

One Spotted Sandpiper (*Actitis macularia*) from the Cassair district, B.C.

One Northern Pacific Kittiwake (*Rissa tridactyla, pollicaris*) from Frances Lake, N.W.T.

A small series of fresh water shells, including some remarkable varieties of *Limnæa ampla*, from Frances and Finlayson lakes and the Lewis River.

Several specimens of graptolites from the presumably Cambro-Silurian shales of the Dease River, and thirty-five specimens of fossils from the Cretaceous rocks of the Lewis River.

Dr. R. W. Ells:—

A series of about 50 specimens of fossils from the Lévis Formation at various localities in the province of Quebec.

Dr. R. W. Ells and H. M. Ami :—

Forty specimens of fossils from the Chaudière River, Q., near the railway bridge.

Twenty specimens of fossils from the Hudson River formation, near St. Nicholas, Q.

About twenty specimens of fossils from Point Lévis and South Quebec.

Several fossils from Champlain Street, and foot of Citadel Hill, Quebec.

About twenty fossils from the Montmorency River, and the same number from Bois Brûlé and St. Blondin, Q.

Prof. John Macoun :—

Fifty-six species of birds, represented by 90 skins, and two mammals, from Vancouver Island; also a large number of marine shells and other invertebrata, and of land and fresh water shells, from the same locality.

R. G. McConnell :—

An interesting series of fossils from the Triassic and Cretaceous rocks of the Liard River.

J. B. Tyrrell and D. B. Dowling :—

450 specimens of Cretaceous fossils, twenty-four of butterflies and three of mammals from Duck and Riding Mountains, in northern Manitoba.

Prof. L. W. Bailey :—

Fossils from the Beccaguimic River, N.B., from various places around Lake Temiscouata, Q., and from Bois Brûlé and St. Blondin, Q.

T. C. Weston :—

About 1,000 specimens of fossils collected at various localities between Cape Rosier and Point Lévis, Q., and about 300 specimens of forty species of Niagara fossils from Grimsby, Ont.

H. M. Ami :—

Collections of fossils from Pointe aux Trembles, Mount Wissick, Tuladi River, Tuladi Lake and other places near Lake Temiscouata.

W. McInnes :—

Silurian fossils from rocks south of Rimouski, Q.

H. P. Brumell:—
Five specimens of fossiliferous Trenton limestone from Campbellford, Ont.

The additions to these departments of the museum, by presentation and purchase, are as follows:—

By Presentation:—

Charles E. Fish, St. John, N. B.:—
Specimen of *Lepidodendron Sternbergii*, from the Millstone-grit of Newcastle, N. B.

J. W. Tyrrell, Weston, Ont.:—
One female "Blue" Fox, *Vulpes lāgopus*, var. *fuliginosus* (trapped January 12th, 1886); one Arctic Fox, *Vulpes lagopus*, in winter coat; one Ringed Seal, *Phoca fœtida* (something under a week old); two Hudson's Bay Lemmings, *Cuniculus torquatus;* one Polar Hare, *Lepus timidus*, var. *arcticus*, in winter coat; all from Ashe Inlet, Hudson's Strait.

G. Seifert, Fabrique St., Quebec:—
Three specimens of the Fresh-water Pearl mussel (*Margaritana margaritifera*) with a number of pearls from the same species.

W. F. Whitcher, Ottawa:—
Skin of Kit Fox (*Vulpes velox*) from Antelope Lake, Assiniboia.

Prof. E. Hull, Director Geological Suruey of Ireland, Dublin:—
Two specimens of *Oldhamia antiqua* from Carrick Mountain, Wicklow, and two of *Oldhamia radiata* from Bray Head, Wicklow.

H. Bartlett, Ottawa:—
Specimen of an Osprey (*Pandion haliœtus Carolinensis*) shot on the Rideau River near Ottawa.

W. P. Lett, Ottawa:—
One Sora Rail (*Porzana Carolina*) also shot on the Rideau River near Ottawa.

Sir William Dawson, C.M.G., &c.:—
Specimen of *Flustra serrulata*, Busk, from Murray Bay.

T. G. White, Ottawa:—
Four specimens of Wilson's Meadow Mouse (*Arvicola riparia*) from near Ottawa.

W. J. Bayley, New Edinburgh:—
One adult female of the Marsh Harrier (*Circus Hudsonicus*) shot at Britannia Bay, near Ottawa.

D. N. St. Cyr, Department of Public Instruction, Quebec;—
One young Harp Seal (*Phoca Groenlandica*) apparently about five or six weeks old.
Specimen of *Hippopus maculatus.*

H. L. Poole, Manager Acadia Coal Mines, Stellarton, N. B.:—
Fine specimen of *Lepidodendron personatum* from the coal measures at Westville, Pictou Co., N.S.

Percy Woodworth, Kentville, N.S.:—
Six specimens of insects and two fœtal mice, from Digges Island, Hudson's Bay.

W. F. MacKay, Fort Albany, James' Bay:—
Three specimens of birds from the Albany district.

By Purchase:—
Head of adult Bull-walrus (*Odobœnus rosmarus*) and skin of a White Wolf (*Canis lupus*, var.), both from Ashe's Inlet, Hudson's Strait. The walrus was shot on the 10th of April, 1886, was eleven feet long and weighed about 2,500 lbs. The white wolf was shot by an Eskimo in the winter of 1885-86, about 30 miles north of Ashe Inlet, or in Lat. 63° N., and Long. 71° 30 W.
Underjaw (with two teeth in place) vertebræ, ribs and limb-bones of *Mastodon* found in 1871 in a peat bog near Woodstock, Ont.
Specimen of an adult female Puma (*Felis concolor*) shot in August, 1887, near Victoria, V. I.
One Red Fox (*Vulpes vulgaris*).
One Kit Fox (*Vulpes velox*) from near Calgary, N.W.T.
One young Whooping Crane (*Grus Americana*) and one adult Franklin's Gull (*Larus Franklini*) both from Manitoba.
Remarkable colour variety of the Rough-legged Buzzard (*Archibuteo lagopus*) shot near Ottawa.

BOTANY.

On the work in this section during the year, Professor Macoun reports as follows:—"In January, February and March, I was occupied with correspondence and in examining and classifying a very large quantity of miscellaneous cryptogamic matter.

"My results have since been submitted to specialists, and their partial reports are now in my hands.

"The collection of Canadian Fungi, upwards of 600 species, now in the Museum, has been named by Mr. J. B. Ellis, of Newfield, N.J.

"Dr. Nils Conrad Kindberg, of Lusköping, Sweden, has examined the mosses, and has confirmed, or corrected my determination, and the list of Canadian mosses has been increased to nearly 600 species, many of them new, not only to Canada, but to science. The Hepaticæ or Liverworts are difficult to determine, but good progress is being made in this work. More than 100 species are now in the hands of Mr. Pearson, of Manchester, who is the highest authority in England on this class of plants.

"On the 8th of April, I left Ottawa for Vancouver Island, arriving there on the 15th. From that time to the end of August, I was occupied in collecting specimens of the flora of the island and in determining the distribution of its forest trees and the character of its soil as indicated by the vegetation.

"My researches extended from Victoria to Connox on the east coast, with frequent excursions to points in the interior. Crossing from Qualicum to Alberni I went in a canoe to Cape Beall on the outer coast. The islands in Barclay Sound were examined, and in prosecuting the examination of the country inland the following mountains were ascended:—

	Feet.
Mt. Erskine on Salt Spring Island	1,275
Mt. Finlayson near Goldstream, Vancouver Island	1,350
Mt. Benson at Nanaimo	3,363
Mt. Prevost at Somenos	2,700
Mt. Arrowsmith near Qualicum	5,976
Mt. Mark at Horne Lake	3,080

Fifteen hundred species of plants were collected.

Since my return in September, I have been fully occupied sorting and determining the specimens collected during the summer, and in writing the fourth part of the Catalogue of Canadian Plants, a portion of which is now passing through the press.

During the year 1886-87 there were placed in the Herbarium 4,305 sheets of specimens, as follows:—

Canadian	752
American	1,807
European	750
Cryptogams	996
	4,304

From the herbarium 5,905 sheets of duplicate specimens were distributed either to individuals in exchange for specimens received, or to scientific institutions. Among the latter were the British Museum, McGill and Queen's Colleges in Canada, and the Harvard University herbarium in the United States.

Dr. Dawson has brought back from his last summer's field of labor on the Upper Yukon a valuable and interesting collection of plants and although but a cursory examination has been made of them, they show conclusively that the summer climate there is neither cold nor wet

Mr. J. M. Macoun acts as botanical assistant during the winter and takes care of the herbarium, while during the summer he accompanies one or other of the exploring parties in the field, taking every opportunity to make botanical and zoological observations and collections. Besides the botanical work here recorded, Professor Macoun made valuable zoological collections during the summer which are referred to in the report on that section by Mr. Whiteaves.

MAPS.

British Columbia.—The map of the western part of Vancouver Island and adjacent coast, scale eight miles to one inch, has been published with Part B of the Annual Report, 1886.

Mr. Bowman during the year has completed the following maps and plans:—

	Area in Square Miles.
1. Revised map of the southern interior of British Columbia, scale 8 miles to 1 inch	28,914
2. Map of Cariboo district, scale 2 miles to 1 inch, about	2,720
3. Plans of eleven creeks showing placer mines and quartz ledges and embracing together about 249¼ square miles, as follows:—	
(1.) Little Snowshoe and Keithley Creeks, scale 2½ inches to 1 mile..........................	54
(2.) Sugar, Hardscrabble and Slough Creeks, 3 inches to 1 mile	49
(3.) Antler Creek, scale (about) 26 chains to 1 inch.	38
(4.) Cunningham Creek do 27½ do do .	34
(5.) Lightning Creek do 400 feet do .	17
(6.) Grouse Creek, scale do 25 chains do .	14
(7.) Island Mountain and Mosquito Creek, scale (about) 480 feet to 1 inch..................	3½
(8.) Harvey Creek, scale (about) 19 chains to 1 inch....................................	3⅛
(9.) Williams Creek, scale (about) 400 feet to 1 inch.	12
(10.) Hixon Creek, scale 2½ inches to 1 mile......	24
(11.) do do about 10 chains to 1 inch..	¾

North West Territory.—Mr. J. B. Tyrrell's map of the country between the Upper Bow and the North Saskatchewan Rivers is engraved, and accompanies Part J., Annual Report, 1886; scale 8 miles to 1 inch; area 45,000 square miles.

Manitoba and Western Ontario.—The map of the Lake of the Woods to illustrate Mr. Lawson's report on that region was published early in the year; scale 2 miles to 1 inch; area 3,456 square miles.

Mr. E. D. Ingall's map of Silver Mountain and vicinity is engraved; scale 20 chains to 1 inch; area 45 square miles. Also sketch map of Thunder Bay mining region; scale 4 miles to 1 inch; area 3,000 square miles.

Mr. Cochrane has continued the revision of sheet 115 in the field from 17th July to the 2nd September, having examined and corrected about 250 square miles. Copies were made of about 55 miles of the plans of the Wellington, Grey and Bruce railway: scale 200 feet to 1 inch.

Mr. Coste has a plan of the townships of Madoc and Marmora, county of Hastings, ready for publication. Scale 2 miles to 1 inch.

For two weeks during the summer Mr. Barlow was engaged surveying roads, range lines, &c., to aid in the compilation of the map of Carleton county. Scale 4 miles to 1 inch.

Quebec.—The south-east ¼ of the Eastern Townships map is completed and will accompany Part J Annual Report, 1886. Scale 4 miles to 1 inch. Area 4,500 square miles.

Professor Bailey and Mr. McInnes are working on ¼ sheets, 17 N. E. and 18 S. E.

The map of Ottawa and Pontiac counties remains as last reported.

New Brunswick.—¼ sheet, No. 2, N. W., has been published. Scale 4 miles to 1 inch. Area 1,512 square miles.

Nova Scotia—¼ sheets, No. 4 N. E. and 4 S. E. are being drawn.

LIBRARY.

Dr. Thorburn reports that 5,075 copies of the various publications of the Survey were distributed during the year, including Annual Reports, special reports and maps. Of these 3,980 were distributed in Canada, the remainder were sent as exchanges to scientific and literary institutions and individuals in the United States, South America, Europe, India, China, Japan, Australia, &c.

The number of reports in French sent out was 563.

There were received as exchange during the past year 1,027 publications, including reports, transactions, proceedings, memoirs, periodicals, pamphlets, and maps.

There were added to the Library during the year 82 publications by purchase, besides 37 scientific magazines and periodicals on geological, mineralogical and natural history subjects subscribed for.

The number of volumes bound was 281.

The letters received in connection with matters relating to the Library and the distribution of the geological publications were 1,211, whereas those sent out during the same period were 1,315.

VISITORS.

The number of visitors to the Museum during the year from the 1st of January to the 31st of December was 17,575 or three thousand more than in any previous year.

STAFF, APPROPRIATION, EXPENDITURE AND CORRESPONDENCE.

The strength of the staff at present employed is 53, viz., professional, 36, ordinary, 17.

During the calendar year the following appointments were made to the permanent staff:—

Mr. Eugène Coste, Mining Engineer.
Mr. Amos Bowman, Field Geologist.
Mr. A. C. Lawson, do

The amount available for the fiscal year ended 30th June, 1887, was:—

Civil-list salaries, appropriation	$40,650 00
General purposes, do	56,995 32
	$97,645 32

The expenditure may be summarized under the divisions named as follows:—

Civil-list salaries	$38,450 00
Wages, temporary employés	19,765 00
Exploration and survey	19,144 58
Indian and Colonial Exhibition	5,700 83
Printing and lithography	11,389 02
Purchase of specimens	865 05

Purchase and binding of books, and purchase of instruments	525 83
Laboratory apparatus and chemicals	89 06
Stationery, mapping material and Queen's Printer	1,087 21
Incidental and other expenses	2,286 47
	$99,303 93
Less paid in 1886	8,837 48
	$90,466 45
Advance to field explorers and others on account 1887-88	3,930 4
Unexpended balance civil-list appropriation	2,200 00
Unexpended balance of contingency appropriation	1,048 43
	$97,645 32

The correspondence of the branch shows a total of 8,489 letters sent, and 5,505 received, from 1st January to 31st December, 1887.

ALFRED R. C. SELWYN,
Director.

1888.

During the summer, between the middle of July and October, I visited and examined certain places for the purpose of investigating questions in connection with the work of the Survey, and the discovery and development of valuable economic minerals. Among them may be mentioned the apatite and iron ore deposits near the village of Carp, in the townships of Huntley and Fitzroy, the borings for gas and petroleum at St. Grégoire and Maison-Neuve in Quebec, at and to the west of Collingwood in Ontario, and near Lake Dauphin in Manitoba. The whole of the month of August was devoted to the study of the great mineral bearing belt which occupies the shores of the north channel of the Georgian Bay of Lake Huron and extends from Sault St. Marie to Sudbury. Within this belt are situated not only the newly discovered nickel-copper and gold-bearing deposits in the vicinity of Sudbury, but also the old and now abandoned Bruce and Wallace mines, and a number of other promising deposits of copper ore, argentiferous galena and iron ore, which seem only to require energy and enterprise to convert them into profitable mines. The Vermilion or Tough gold mine near Whitefish station on the Sault St. Marie branch of the Canadian Pacific Railway was visited. Some of the rock obtained from the vein is mar-

vellously rich in visible free gold, but it is not easy to predict what the future of these mines will be. At the date of my visit, only one shaft, which strangers were not permitted to examine, had been sunk on the deposit, apparently a bed of quartz two to three feet thick running with the stratification, or about E.N.E and W.S.W., in a vertical attitude. Fine grained diorite, and altered greenish sandstone and schists of the usual Huronian type constitute the country rock, and on the summit of a ridge of this diorite, a few hundred yards to the south, a pit about 20 feet deep had been sunk in a fragmentary ferruginous mass which shows both free gold and films of native copper, while pyrrhotite, and yellow and purple sulphurets of copper occur impregnating the diorite as they do in the Stobie, Copper Cliff and Evans mines at Sudbury. The general geological features of this region appear to correspond very closely with those observed around the Lake of the Woods where also a number of gold-bearing quartz veins have been discovered, one of which, opened during the past year about seven miles S.E. from Rat Portage, opposite Quarry Island, has afforded a large number of specimens, even richer in free gold than those from the Vermilion Mines. The vein is a somewhat ferruginous quartz traversing a dioritic or hornblendic schist near its contact with the granite mass of Quarry Island, and if the material can be got in quantity the owners have here an exceptionally rich mine. It is known as the Sultana mine, but does not appear to be the same vein as that described by Mr. Coste, p. 17 K, Geological Survey Report 1882-84, as the Sultana Lead, and of which he says, "I do not think it is auriferous."

The subject of natural gas in Canada was referred to in my last summary report. Since then I have informed quite a number of enquirers that almost in any part of the Ontario peninsula, more especially south and west of the outcrop of the Trenton limestone which extends from Port Hope to Collingwood, the chances of striking natural gas and petroleum are as good as they are in Ohio. I am informed that several borings are now in progress to test the question, and steps have been taken to secure an accurate record, and samples for examination, of the strata passed through in these borings.

Cost of season's work was $852.60.

Dr. G. M. Dawson, assisted by Mr. J. McEvoy, was occupied during the past summer in carrying out a somewhat detailed geological examination of part of the southern interior of British Columbia. This region had been subjected to a general geological reconnaissance by Dr. Dawson in 1877, and a preliminary geological map and report were published as the result of the work. Since the completion of the

Canadian Pacific Railway, however, the importance of this particular portion of British Columbia has much increased, and Mr. A. Bowman was in consequence instructed to carry on work there in 1882 and 1883. Much of his time was devoted to topographical measurement and delineation, as the physical features of the region are very complicated and in some places hold a close relation to the geological structure. A map embodying the result of Mr. Bowman's geographical work was prepared and published last winter, and is a great advance on anything previously existing for the region covered by it, which is practically identical with that of Dr. Dawson's reconnaissance map of 1877. This map was regarded as the basis for a more detailed geological map, but from the complicated geological structure which Dr. Dawson's close examination during the past summer has revealed in some parts of the district, it may perhaps eventually be found desirable to complete the geological map on a larger scale. Dr. Dawson furnishes the following outline of his work, in connection with which he left Ottawa on the 14th of June, returning on the 30th of October :—

"On beginning the work of the past season, I thought it probable that with the information already in hand it might be possible to revise the geology of the arena covered by the map of 1877 and 1887, and to re-examine the various doubtful points within the area in the course of the summer. Before field work was begun, however, I arranged to meet Mr. Bowman, and on discussing the matter with him found that more than I had supposed remained to be done, and later, as the work progressed, unexpected complications of structure presented themselves, rendering necessary a close re-examination of certain parts of the district. There were also considerable gaps in the geographical outlines and topography of the map which we were obliged to fill, and it soon became evident that it would be better to go over a portion of the region in a somewhat detailed manner than to make disconnected observations over the entire area of the sheet. The operations were, therefore, practically confined to a district having an extreme length of about 130 miles with an extreme breadth of about 70 miles, which occupies the central portion of the map sheet above referred to.

"The geographical and topographical part of the work was chiefly performed by Mr. McEvoy.

"The geological observations have cleared up several points previously in doubt and have resulted in the definite outlining of the principal formations in the area covered, but much yet remains to be done before the present observations can be presented in a connected and satisfactory form, in combination with the facts ascertained by Mr. Bowman, as a supplement to those of 1877. I shall, therefore, here confine my remarks to notes on certain points which appear to have an immediate economic interest.

"The discovery of coal in the vicinity of Kamloops, which occurred last winter, has attracted some attention to the coal question in this interior part of the province, and was one, among other reasons, for the present re-examination of the district. The coals found in this region occur at the base of the Tertiary formation, in beds of ordinary sedimentary origin, while the upper portion of that formation is composed of volcanic rocks, largely basalts. Unlike most Tertiary fuels, however, these were found, in some places, to assume the character of bituminous coals. This is the case with one of the seams known for many years near the junction of the Nicola and Coldwater Rivers, and also with that of the Indian Reserve on the North Thompson. These localities, with others in which lignites occur, are described in the Report of Progress for 1877-78. The coal near Kamloops is also a bituminous coal, and though the seams so far found are quite thin, the locality appears to be worthy of examination on account of its nearness to the railway. The rocks in which the coal occurs form a local extension of the Tertiary basin which is somewhat wide-spread in the vicinity of Kamloops Lake, and even should no really workable bed be found at this spot, the mere occurrence of coal here points to the probability of the existence of thicker seams elsewhere in the basin. Excellent lignite, in seams of good thickness, has lately been found near Vermilion Forks on the Similkameen, but from the isolation of this locality can at present be of local use only. The lignite reported near Quilchana on Nicola Lake is of inferior quality and scarcely suitable even for local use.

"The work of the past summer has proved that the sandstones, shales, &c., with which the coal is associated really underlie but limited portions of the whole area covered by the Tertiary rocks, and appear to have been deposited in isolated basins, a fact scarcely realized before. This renders the thorough examination, by boring or otherwise, of the localities where either coal or lignite occurs very desirable. A further study of the region near the confluence of the Nicola and Coldwater Rivers indicates that this is one of the most promising places for coal mining which has yet been discovered in the region.

"While speaking of the Tertiary formation, it may be noted that important beds of trachyte occur in a number of places among its volcanic materials, and that in one of these, a few miles to the north-west of the head of Stump Lake, opaline silica and hyalite were found to be developed in small vesicular cavities. While nothing which can be classed as precious opal was actually observed, the locality would appear to be worthy of close examination, as the matrix is identical in character with that yielding precious opal in Hungary and elsewhere.

"The working of placer gold deposits has been in progress for many

years in a number of places scattered over this region, and though no extremely rich deposits like those of Cariboo have been discovered, a large amount of gold has been obtained in the aggregate, even without including that got along the Fraser and Thompson Rivers. Tranquille River, Cherry Creek, Mission Creek and the Similkameen River have been almost or quite continuously worked since their first discovery, either by whites or Chinese, and still continue to yield remunerative quantities of gold. The discovery of Granite Creek, a tributary of the North Similkameen or Tulameen, in 1885, with the late renewal of placer mining on a considerable scale on the Tulameen itself, seems to show that paying auriferous creeks may still remain to be found even in this comparatively well known part of the country. The area of good ground on Granite Creek was found eventually to be less considerable than at first supposed, and comparatively few claims are now being worked there, but several of the streams in this vicinity have since been worked with success. Of these Boulder Creek, a small stream running into Otter River, is at present the most important.

"The most interesting feature which has been developed in connection with mining on the upper part of the Similkameen and Tulameen and their tributaries is the occurrence everywhere of platinum in association with the gold. This association is mentioned in my report of 1877, in connection with the placers of Whipsaw Creek, where, however, both the gold and platinum are found only in fine scales. On the discovery of Granite Creek it was found that with the "coarse" or "heavy" gold obtained there, platinum of a similar character was also associated. In all about 1,400 ounces of platinum was sent out from this region in 1887. The close and constant association of the platinum with the gold renders it nearly certain that both are derived from a common source, to be found in the rocks of the immediate vicinity.

"Some attention has lately been paid to the search for lodes in the vicinity of the Tulameen, and a number of locations have been taken up, but nothing except a limited amount of preparatory work has yet been done toward their development. I may state, however, that the district appears to be worthy of attention by the prospector, as it presents very favorable indications, and the rocks often show evidence of solfataric action, being highly silicified and holding much pyrites in certain belts.

A specimen of ore collected by myself at the "Bonanza Queen" location has since been found by Mr. Hoffmann to contain 1·3 ounces of gold, and 5·1 ounces of silver, to the ton of 2,000 pounds.

"A remarkable indication of the existence somewhere in the Tulameen Basin of extremely rich ores is found in the discovery in sluice-boxes

on the river, about thirteen miles above Granite Creek, of small rolled pellets of pure silver-glance strung through with filamentous gold.

"In the vicinity of Stump Lake the principal mining developments are comprised within an area about five miles in length, with a variable breadth, running nearly north and south on the east side of the lake. A large number of mining claims have been taken up in this vicinity, and numerous prospect holes and small trial shafts have been sunk. The greatest amount of work has so far been accomplished on the property of the Nicola Mining Company, under the superintendence of Mr. W. Craib. and on the adjoining property of the Star Mining Company, under Mr. G. Henderson. A considerable amount of work has also been done on the Hepburn group of claims on the opposite side of the valley and further south than those first mentioned. Operations were temporarily suspended on the last mentioned claims at the time of my visit, but some of the richest ore, of which very satisfactory trial shipments have been made, has been obtained at this place.

"The metalliferous veins which have been found within the limited district above defined are very numerous. They vary from about ten inches to five or six feet in width and some of them have been traced for a length of several hundred feet. Though it is probable from the great number of veins which exist that no single one will be found to be continuous for a very great distance, a large supply of ore is already assured. Most of the veins run with very considerable uniformity in bearings a few degrees west of true north, or from N. 10° W. to N. 30° W. magnetic. There are, however, a few which diverge widely from this direction, and two or three which run nearly at right angles to it. The gangue is generally white quartz, and the principal metalliferous minerals present include iron and copper-pyrites, galena, blende and tetrahedrite. Assays made by Mr. Hoffmann, in the laboratory of the Survey, run from 15 to 406·5 ounces of silver, with 0 to 6 ounces of gold per ton of 2,000 lbs., according to the relative amounts of the various mineral constituents. The country-rock consists of altered volcanic materials, probably of Palæozoic age, and may be generally characterized as a diabase-porphyrite, the most characteristic material in this place being a rock of green and green-grey colour with coarse porphyritic crystals of plagioclase and pyroxene.

"On the whole, the prospects for the immediate development of an important mining district are here most encouraging. The occurrence of these ores in the green, altered volcanic rocks, which, under slightly varying forms, occupy so large an area of the southern interior of British Columbia, is a feature of peculiar interest, inasmuch as it leads to the belief that these wide-spread rocks become a metalliferous series where the other conditions are favorable. What these precise condi-

tions are, beyond the existence of fissures in which the segregation of metallic minerals has occurred, we are yet unprepared to say. Massive granite rocks occur a few miles to the west of the mineral belt of Stump Lake, and while a similar rock may underlie its surface at no great depth in the mineral belt, there is nothing to indicate that the ores partake of the nature of contact deposits.

"Another metalliferous locality to which some attention has been drawn, and which was visited during the summer, is situated near the lower part of Jamieson Creek, fifteen miles up the North Thompson. Very little work has yet been done here, though a number of claims have been recorded. The veins occur in a mass of greyish granite, which breaks through certain black micaceous schists or argillites, which form an important intercalation in the Palæozoic rocks, generally of volcanic origin, of this part of the province. The granite is highly siliceous in the vicinity of the veins, and these appear to have been produced contemporaneously with the intrusion of its granite. The gangue is quartz and it shows pyrites with a little galena, blende and tetrahedrite. Assays made by Mr. Hoffmann show from $\frac{7}{10}$ to 1 ounce of gold and $2\frac{1}{2}$ to 34 ounces of silver to the ton. Little can as yet be proved respecting the continuity of the veins in this district, and the area within which claims have been recorded is comparatively small. The surface display of quartz is, however, considerable, and this, with the rich character of the ores, would appear to warrant some expenditure of a tentative character. The widest vein seen is from five to six feet. It may further be mentioned in this connection that fragments from similar veins were seen by us near the headwaters of Jamieson Creek.

"It is here only possible to mention some of the principal localities visited without entering into detail respecting them, and space cannot be accorded even to include mention of the numerous isolated "prospects" which have, of late, been brought to light. The mines of Cayoosh Creek and those of Rock Creek, though comprised within the area of the map first referred to, were not visited though encouraging reports have been received from both, and assays of specimens yield well in gold. At Cherry Creek also, a new company has undertaken a thorough examination of the very rich silver ore found there, but of which some difficulty has been found in following the vein. Some account is given by Dr. Selwyn, in the last summary report, of the deposits of argentiferous galena in the Selkirks, particularly near Illicillewaet. The exploration of some of these has been quietly but persistently carried on during the past summer. Work has also been in progress on the Monarch and Cornucopia claims at Mount Stephen, and prospecting operations in a number of localities on the eastern slope of the Selkirks.

"The Toad Mountain and Kootanie Lake districts have attracted much notice during the summer, and a large number of prospectors and miners have been at work there, with most encouraging results. Though I have not myself visited these localities, it appears certain that they require only to be brought within the reach of the railway to ensure a large output of argentiferous galena, some of which is of high grade. Some trial shipments have already been made, of which one of 22 tons, from the Silver King claim, sent with considerable difficulty to Butte, Montana, realized a gross amount of $6,463, chiefly in silver.

"Amongst other items bearing on mining enteprise in the province in general, may be mentioned the establishment, which is in progress under the government of British Columbia, of a test mill in Cariboo, and the erction of a smelter, with a capacity of 50 tons per diem, by the British Columbia Smelting Company (Limited) at Vancouver.

"Of the various enterprises on the coast it is impossible to give particulars here, though it may be noted that Mr. Dunsmuir has commenced work on the opening up of a portion of the Comox coal field, while renewed efforts were in progress with a view of making a thorough test of the anthracite of the Queen Charlotte Islands.

"Notwithstanding the great activity in placer gold mining in British Columbia in the years following its discovery in 1857, and particularly after the finding of the phenomenally rich placers in Cariboo, in 1860, the subsequent development of metalliferous mining in its more permanent forms has been slow. This circumstance has been due to several causes, which need not here be discussed, but one of the chief drawbacks has always been the want of proper means of transport for heavy machinery and for ores. It is therefore extremely gratifying to find that, as an immediate consequence of the building of the Canadian Pacific Railway, that part of the country in its vicinity is rapidly beginning to evince its character as a rich metalliferous district, and to justify the confidence which those best informed on the subject have always felt as to its ultimate great value. The general knowledge which we now have of the geology of the province as a whole, is such as to show that, when similar means of travel and transport shall be extended to what are still the more inaccessible districts, these also will prove to be equally rich in minerals, and particularly in the precious metals, gold and silver.

"It is true that we have even in the southern part of the province to chronicle as yet merely the inception of "quartz mining," but so much has (even already) become known, and the deposits discovered in many cases carry ores of such high grade, that I feel no hesitation in stating my belief that the district is now on the verge of an era of

mining activity of great importance. The establishment of mining centres in different parts of the country, will react on all other industries, and in particular will supply just that local demand for produce which is required by the somewhat scattered character of the agricultural lands.

" I must also add that in comparing the degree of settlement, cultivation and progress of the ranching industry in the portion of British Columbia here particularly referred to, with that of these industries at the time of my previous work in the same district eleven years since, evidence is everywhere apparent of substantial progress. I was particularly struck with the fact that, even in the higher and more secluded valleys, settlers are now taking up land, and finding that crops may be successfully grown and stock raised, where in the more easy-going early years of the province no one would have attempted either. With this particular fact of evidence, it is worth calling renewed attention to the circumstance that in the further northern parts of British Columbia, particularly in the basin of the Nechacco and its vicinity, there exist relatively extensive tracts of low cultivable land. It would appeared that the time has now almost arrived when the settlement of these may be undertaken with advantage."

Cost of season's work was about $1,950.

On the seaboard of British Columbia, Mr. Amos Bowman commenced field work in New Westminster District on the 1st of April, continuing to the end of August. The area delineated comprises a rectangle of a degree of latitude lying north of the 49th parallel, and three degrees of longitude lying eastward from the Gulf of Georgia to the cañon of the Fraser. In this region are situated the cities of Westminster and Vancouver. It includes the delta of the Fraser, and also the much larger pleistocene delta of that stream. A considerable expanse of lignite-bearing Tertiary, and also of bituminous coal bearing rocks of Cretaceous age, occur in this region, the two series presenting a system of outliers and ranges flanking the higher coast mountains of granite.

In May and June the limits of the Tertiary were traced, first south of the Fraser, commencing at Mud Bay (Semihamoo) and thence eastward to the Chilliwack River Mountains. The same rocks were then delineated (and incidentally others) on the north side of the Fraser, especially in the vicinity of Westminster and Vancouver.

Workable beds of lignite and coal, in the older as well as in the newer series of rocks, are believed to exist, and will be developed when prospecting for them by boring, or drifting to depths beyond atmos-

pheric influence, is undertaken. In the adjacent United States territory the same rocks have been more extensively prospected, and in several places, where exploited, show every indication of the prevalence and continuance of favorable coal making conditions along the whole eastern or mainland side of the Puget Sound and Fuca Strait, from the southern extremity of the former as far northward as the valley of the Fraser—in other words, on the Westminster side of the trough as well as on the opposing Vancouver Island side. The older or Cretaceous series of rocks are extensively developed in Canadian territory in the Harrison Lake district, and in the south-eastern portions of the field described.

The quantity of Tertiary coal or lignite, which may be developed by means of judicious boring operations in the vicinity of Westminster and Vancouver, can only be conjectured by the experience at Bellingham Bay, which furnished one of the earliest examples of profitable coal mining on the Pacific Coast; the basin there and its rocks being continuous, it may be fairly inferred that the coal seams are so also.

Although coal has been found in very many localities north of the international boundary-line in the Tertiary delta of the Fraser, in only two instances have attempts been made, by sinking or boring, to ascertain the thickness of the seams at depths where they would be uninfluenced by atmospheric weathering, and in both instances without adequate capital—at Coal Harbour (Vancouver) by a boring, and at Sumas Mountain by an incline. The results, so far as they go, are by no means discouraging.

The quality of this Tertiary coal is somewhat superior to that of Mount Diable in California, which has there served a most useful purpose.

The conditions now existing, which justify prospecting by boring operations, and mining lignite for local use, are its cheapness, and a local market greatly extended beyond that heretofore existing; which would enable it now to successfully compete for many purposes with coal transported from Vancouver Island.

Proximity to croppings of seams known and considered to be more or less promising, so as to test these at a distance from the surface, would be the first consideration in selecting sites suitable for boring operations. Otherwise located, a bore hole might be put down very widely astray, and might succeed only in testing a theory; but thus guided the bore could not fail to test the ground in association with the seam or seams in question to the depths explored.

The thickness of the measures desirable to be tested in the same connection will of course govern the depth of the bore in any given locality. The entire series exposed in the vicinity of Burrard Inlet is

not far from 3,000 feet in thickness. But all these beds, except some unknown, possibly underlying ones, come to the surface; those exposed nearest to the Inlet being at the bottom and those nearest to Fraser River at the top of the series. A bore near Port Moody, say at the terminus of the "North Road," would test the lower series; but could reveal nothing respecting the next overlying strata, which at that place have been removed by denudation. To test these it would be necessary to go as far up the coal ravine of the "Gravel Pit" (nearly opposite the north arm of Burrard Inlet, known also as camp No. 2, and the "Italian Camp," on the railway) as it would be possible to haul the boring machinery. The same rocks would be far below the surface at Burnaby Lake, and probably several thousand feet beneath the city of Westminster.

A very short incline, shaft or tunnel, might test the ground satisfactorily in one place, while a bore of several hundred feet might suffice at another; the choice being determined by the contract price. Sinking by shaft, necessitating pumping of water, would be undertaken only after the ground has been tested, and proved to justify that expense.

Boring for water, a question of present public interest, is quite another problem, if the water be looked for in the porous gravelly or sandy strata overlying the coal, as at Westminster. In a bore theie, for an artesian well, a depth of from one to two thousand feet would have to be attained before any coal yet found could enter into consideration at all, and at such depth, even if found in that vicinity, it could not be profitably worked.

Cretaceous coal measures already referred to, lie probably too deep in the littoral district under consideration to be reached by boring, except possibly in certain localities along the south shore of Burrard Inlet, where a bore would probably go through some shore edges of the Cretaceous before reaching the underlying granite; such as opposite the valleys of the North Arm and of Pitt River, both of which may represent arms of the Cretaceous sea.

Any point between the smelting works and the terminus of the "North Road," would be suitable for a bore to search for the deep lying Cretaceous coal measures in this vicinity. That of the coal croppings on Hastings town site, half a mile west of Hastings, is as favorable as any other; and presents, in addition, the inducement of connected and interesting developments in the Tertiary series.

At Sumas Mountain, and at the Warnock-Kanaka Creek Mountain, the Tertiary coal, so far as known, lies near the botton of the series. Kanaka Creeks presents a favorable locality for test by boring in the line of the ancient valley of the Lillooet River.

Two series of coal seams come to the surface on opposite sides of the city of Vancouver. The coal measures occupy the whole of Stanley Park, and also immediately underlie the city. By means of a bore of over 400 feet put down near Granville Hotel, Vancouver, nearly twenty years ago, some lower beds of the series coming to the surface in Stanley Park have been proved to be either noncontinuous or barren. But the seams which have given Coal Harbor its name more probably escaped the investigation of the prospectors altogether, from the circumstance that the locality selected appears to have presented only strata overlying the coal. The upper coal croppings of Brewery Creek, and other localities on the south side of False Creek, do not anywhere extend to the northward of False Creek. They could be conveniently intersected by a bore on the line of the False Creek trail to Fraser River, which could be so located as to reach the coal at any desired depth below the surface.

Cost of season's exploration was $1,216.05.

Mr. R. G. McConnell, who left Ottawa on the 22nd April, 1887, and crossed from the Yukon to the Mackenzie River, where he passed the winter, as mentioned in the summary report for 1887, returned to Ottawa on the 15th of October last, and now furnishes the following statement respecting this exploration :—

" I separated from Dr. G. M. Dawson at the mouth of Dease River, on the 25th June, 1887, and commenced the descent of the Liard the next day, accompanied by two white men, John McLeod and Louis Trépanier, and a couple of Indians who had agreed to go as far as the Devil's Portage, but became frightened at the first rifle and could not be induced to go farther.

" The evil reputation of this river has not been exaggerated, and it requires careful steering and hard work to navigate it with safety. It is constantly interrupted with rapids and hemmed in by narrow cañons which render frequent portages necessary. The most dangerous part of the river is included between the Little Cañon and Hell Gate. In this distance of about one hundred miles it has a fall of over a thousand feet, and in high water is simply one long cascade.

" The two longest portages are the Portage Brulé, two miles, and the Devil's Portage, which is four miles long and passes over a steep wooded hill 1,000 feet high. At the latter portage we were obliged to abandon our wooden boat owing to its weight and the impossibility of getting it across the portage, and rig up a small sixteen feet canvas boat with which we shot the remainder of the rapids. Escaping through Hell Gate the rapids are left behind, and from that on to near its mouth the river is free from any obstacles to navigation.

"Two days after reaching smooth water I met some Hudson Bay voyageurs going to Dease River, and I took advantage of the opportunity thus afforded of sending my men back to the coast, while there was still time for them to get out the same season. After the separation I drifted down alone to Fort Liard, and obtaining there, after a short delay, a bark canoe and an Indian boatman, proceeded to Fort Simpson where I arrived on the 5th August.

"At Fort Simpson I met Mr. Cummings who had charge of the Mackenzie River district in the absence of Mr. Camsell, the chief factor, and made arrangements with him for wintering at Fort Providence, a fur trading post belonging to the Hudson Bay Company, situated on the Mackenzie River, about forty miles below Great Slave Lake. From Fort Simpson I took passage on board the Hudson Bay Company's steamer "Wrigley" to Fort Smith on Slave River, and embarking there in a bark canoe with a couple of Indians I spent the remainder of the season on Slave River, Salt River, and Hay River, and in coasting round part of the north side of Great Slave Lake, reaching Fort Providence again about the 1st October, where I was hospitably received and treated during the winter by Mr. John Reid, the officer in charge.

"Exploratory work was necessarily suspended during the greater part of the winter, but rough traverses were made at intervals to Lake Bis-tsho, Fort Rae and other places in the vicinity of Fort Providence, and while staying at the post, the work of the preceding summer was plotted, and a complete set of meteorological observations recorded.

"I left Fort Providence on the 1st of May, travelling on the ice with dogs, and reached Fort Simpson on the 6th, where I remained until the river became sufficiently free from ice to allow travelling by boat.

"The river broke up on the 13th of May, but continued full of drift ice all the month. On the 28th of May, having had a boat built at Fort Simpson in the meantime, I left that post accompanied by two Indians, and spent about a month descending and examining the valley of the Mackenzie as far as the mouth of the Peel, and in ascending the latter river to Fort McPherson. Here a delay of a few days was caused by the non-arrival at the appointed time of the Mackenzie River boat, on which I depended for some supplies. The delay was, however, utilized in making a short trip up Rat River to the mountains, and being informed that neither boats nor canoes were to be had west of the mountains, but that the one I had used on the Mackenzie might be portaged across by taking it up Rat River and down a branch of Bell River on the other side, I sent five Indians to try and take it across.

"On the 12th of July, the Mackenzie boat not having arrived, and not knowing how long it would be delayed, I decided not to lose any more time waiting for it, and started across the mountains by the summer portage, reaching Lapierre's House on the 15th. This portage is about sixty miles long, and at the summit of the range attains an elevation of 2,500 feet. The walking is difficult and wide reaches covered with *Têtes des Femmes*, alternating with soft moss-covered muskegs, are met with all the way across. It is crossed by Indians carrying a load of forty pounds, besides supplies for the trip, in four days.

"Leaving Lapierre's House on the 16th July, with an ex-employé of the Hudson's Bay Company, whom I engaged to go to the coast with me, we reached Rampart House on the 20th and Fort Yukon, at the mouth of the Porcupine, on the 24th. From this point the coast and outside communication can be reached, either by descending the river to St. Michael's, or ascending it to the head of the Lewes, nearly 1,000 miles, and crossing the coast range by the Chilkoot Pass. The former is by far the easier route, as the lower Yukon possesses a strong steady current and is free from dangerous rapids, but as it lay altogether outside of Canadian territory, I decided if possible to try and ascend the stream. To do this in a short square-sterned boat, proved, however, to be a matter of no ordinary difficulty. In many places neither tracking nor poling was possible, and progression was only attainable by clinging to the overhanging branches and pulling ourselves up foot by foot. Fortunately the men worked well and we arrived at Forty-mile Creek after a laborious trip of fifteen days. At this place, which is the head-quarters of the miners on the Yukon, I had a suitable boat built, and the ascent of the upper part of the river was made without difficulty. We left Forty-mile Creek on the 14th August, and arrived at Chilkoot Pass on the 15th September, Juneau on the 21st, and Victoria on the 1st October. The total distance travelled from the time I left the coast at Fort Wrangell until I rejoined it again at the head of Lynn Canal, was 4,200 miles, 3,200 miles by water and 1,000 miles on foot.

"The general results of the exploration have not been worked up yet, but will be given in the next report of the survey. In the meantime it may be stated that the geographical results obtained include traverses of the Liard from Dease River to the Mackenzie, of the lower part of Hay River, and of Bell River and the Porcupine from Lapierre's House to Fort Yukon, and that, over the whole route travelled, in addition to the geological work, notes were taken on soils, trees, &c., and on the general capabilities of the country with regard to agriculture.

"During the past summer from two to three hundred men were engaged in working placer deposits on the Yukon and its tributaries,

but owing to continued high water these proved much less remunerative than in the preceding years and the total yield of the district would probably not exceed $20,000. Mining and prospecting on the Yukon has heretofore been confined entirely to river diggings, and no attention has been paid to the extensive system of quartz veins and ledges, which are found all along the river from the boundary, up to White River, a distance of 150 miles, and which afford the greatest promise for the future. In the Mackenzie River valley the petroleum bearing beds were found to have a much wider distribution than expected, and although the distance from a market prevents the utilization of these at present, they will become exceedingly valuable in the future, when the supply of oil from more accessible regions is diminished or exhausted."

The total amount paid during 1887 and 1888, on account of the exploration in the Yukon and Mackenzie districts, was $7,714.08, of which sum Dr. Dawson paid in 1887, in connection with his own and Mr. McConnell's explorations, $4,426.25, the balance, $3,287.83, being Mr. McConnell's expenditure for 1887 and '88.

Mr. J. B. Tyrrell, assisted by Mr. D. B. Dowling, was engaged during the winter of 1888 in plotting and compiling the surveys of the valleys of the Assiniboine and its tributaries, and of the Duck and Riding Mountains, for the purpose of making a map of that hitherto almost unknown district. A profile map on a scale of eight miles to an inch, with 100 feet contour lines has been made, and is now in the hands of the engraver, and will be published during the present winter. It will eventually form part of a larger map of north-western Manitoba, the publication of which must now be delayed for a year on account of Mr. Tyrrell's illness during the past season.

During the season of 1887, a number of enterprising gentlemen of Manitoba sank an eight-inch bore hole on the banks of Vermilion River to a depth of 300 feet in the hope of obtaining a supply of petroleum. Mr. Tyrrell was then consulted, and they were told that they would have to bore through Cretaceous shales to at least 420 feet below the surface, below which they would in all probability shortly strike the Devonian limestones. If petroleum was to be found, as far as there was any evidence to show, it would be in the beds immediately overlying this limestone. During the past summer the bore was sunk to a depth of 743 feet, the Devonian limestone having been struck at a depth of 422 feet, two feet below the depth stated by Mr. Tyrrell. Flows of salt water are reported from the well, but no petroleum or gas.

During the summer Mr. Tyrrell was engaged in continuing the work begun in 1887 in north-western Manitoba. The shores of Lakes Manitoba, Winnipegosis and small surrounding lakes were to be examined and as much of this work as possible was accomplished. The travelling in connection with the work in the west has, up to the present, been largely accomplished with the aid of horses and carts, but this summer most of the horses having been sold, two nineteen feet Peterboro' canoes were purchased and shipped to Westbourne, where they were awaiting the party on its arrival. Mr. Tyrrell reports as follows :—

"We left Ottawa on the 7th of June and proceeded at once to Winnipeg. Here a short time was spent in obtaining necessary supplies, which were at once shipped to Westbourne, whither Mr. Dowling had gone a day or two before to have all the camping outfit got ready for the summer, and if possible to obtain men. For this latter purpose, however, it was necessary to cross the lake to St. Laurent, where two canoemen were obtained.

"On the 13th June I left Winnipeg for Portage Laprairie, where Mr. W. R. Baker, General Superintendent of the Manitoba and North-Western Railway, kindly ordered a railway velocipede to be placed at my disposal. Proceeding by train westward to Minnedosa, I there obtained the velocipede and a man, and thus accompanied examined all the cuttings on the railway between Minnedosa and Langenburg, and the material thrown out of the wells at and between the different stations.

"On this trip much useful information was collected, referring in the first place to the character, structure and mode of accumulation of the superficial deposits. The numerous small cuttings show that the surface is in part underlain by glacial till, in part by the sediment laid down in ancient lakes, and along the rivers, in places, by flood-plain deposits. In the next place the cuttings along the sides of the wide valleys of the little Saskatchewan, Bird Tail and Assiniboine Rivers show excellent sections of the underlying Cretaceous (Pierre) shales.

"On the banks of the latter river, near Millwood, these shales, which are of a dark blue-grey color, contain many, both large and small, nodules of limestone or calcareous ironstone. Some of these, when broken, are found to contain fossils, and from them an interesting collection of about twelve or fourteen different species was obtained.

"Returning to Minnedosa, I was requested by a number of gentlemen to go with them up the valley of the river, for a short distance, and examine a property, where a drift had been run into the side of the bank in the hope of finding coal. After making an examination of the bank, which consisted of dark grey Cretaceous shale, I was obliged to state that there was no indication of the presence of coal.

"Returning from Minnedosa to Westbourne, where Mr. Dowling was camped on the bank of White Mud River, we started in canoes down the stream to Totogan. From there we coasted along the west side of Lake Manitoba to Manitoba House, the shore being generally low throughout, and everywhere composed of alluvial sand and gravel.

"At Manitoba House we obtained another canoe, with an Indian, and proceeded to make an examination of the shores of the northern part of Lake Manitoba. Following the eastern side of the lake as far as the head of Fairford River, we descended this stream to St. Martin Lake.

"Sending Mr. Dowling with a patent floating log to make a survey of this lake, I set out on foot with some Indians, and travelled back from the lake to examine a deposit of gypsum which had been reported to exist in that locality. It was found to be a thick deposit of white, or in places crystalline and transparent gypsum, and to extend, apparently, in lenticular masses and bands, over very large areas. As this deposit is readily accessible it will be of great economic value in the near future, being destined to furnish Manitoba and the surrounding territories with land plaster and plaster of Paris, both of which must now be brought from Michigan, Iowa, Ontario, or more distant places. It can be quarried without difficulty, and can be readily removed by water; or if the proposed Hudson's Bay railway should be built on the east side of Lake Manitoba it will pass through this area and the quarries would then be within one hundred and fifty miles by rail from Winnipeg. Returning to Lake St. Martin, the shores and islands were examined, some of the latter being found to be composed of good, compact and generally coarse-grained granite (Laurentian).

"After having made the examination of Lake St. Martin we returned to Lake Manitoba, and examined its shores to Water Hen River, up which we proceeded to a trading post belonging to the Hudson's Bay Company.

"From here I sent Mr. Dowling on to Lake Winnipegosis to make a micrometer survey of its eastern and northern sides while I returned to Manitoba House by the west side of Manitoba Lake, making a survey with a patent log of the shores and islands as we passed along.

"Arriving at Manitoba House on Saturday evening, 21st July, I was much pleased to meet Mr. Whiteaves, palæontologist and one of the assistant directors of the Survey, who had arrived direct from Ottawa a few hours before. He had come out to join me for a few weeks for the purpose of studying the palæontology of the Silurian and Devonian rocks of Manitoba, as seen in the field.

"After obtaining an additional canoe, and necessary supplies for a month, we started northward together and examined all the principal

rock exposures around the lake, making a large collection of Devonian fossils, many of which are either new species or were now found for the first time in Manitoba. It had been our intention to examine some of the rocks in Lake Winnipeg, and for that purpose we started down the Fairford River on 10th August, but before we had reached Lake St. Martin, I was seized with an attack of typhoid fever and carried back to the mission at Fairford, where I was received with the greatest hospitality by the Rev. J. Bruce, the Episcopal missionary to the district. From Fairford I was removed to Manitoba House, and thence, by Westbourne, to the General Hospital at Winnipeg, which was reached on the 23rd August. Here I was obliged to remain for the rest of the season.

"Mr. Dowling, after he had left me at the Water Hen River on 18th July, proceeded up the east side of Lake Winnipegosis, surveying it with a compass and micrometer as far as Mossy Portage. Birch Island was also surveyed in passing. Close to this portage there is a meridian township line, which was run by Mr. Wm. Pearce, D.L.S., along the lake on the ice in the winter of 1880. From this line Mr. Dowling made a survy with a transit and micrometer of the north shore of the lake to the mouth of Overflowing River, where he connected with the termination of the survey made in a similar manner by Mr. J. L. Dufresne, D.L.S., in 1887.

"He next surveyed with compass and micrometer the Overflowing River for thirty-seven miles up from its mouth, the Armit or Red Deer River up to the lake, which was found to have an area of about a hundred square miles, and the river for twenty-two miles above the lake. He also connected the final point of Dufresne's survey of the Swan River with the chain survey of the higher part of that river made by Mr. Wm. Wagner, D.L S., in 1878, on the ice. He then made a survey of the islands in Dawson Bay. Since I was unfortunately prevented from meeting him according to arrangement, he paid especial attention to the rocks met with, and made a good collection of fossils.

"He left off work on 11th October, and reached Westbourne on the 27th of the same month, where he left his canoe. After settling all outstanding accounts he returned to Ottawa.

"Twenty-seven photographs of different points of interest round Lake Manitoba were taken during the year.

"Three horses and a buckboard were sold during the year, and there yet remains with Mr. Sinclair, at Rossburn, Manitoba, one horse, with two carts and harness, and some old saddles and pack saddles. The two Peterboro' canoes taken out in the spring are still in good order and ready for another season's work.

"Cost of season's exploration $1,923.44."

Dr. A. C. Lawson, assisted by Mr. Smith, was occupied during the early part of the year in completing his report of the southern part of the Lake of the Woods and Rainy Lake, which is now being printed and will form part of the Annual Report, Vol. III, for 1887-88. In June, on my recommendation, leave was granted to Dr. Lawson to proceed to England to attend the meeting of the International Geological Congress in London. The chief subject to be discussed at the Congress was the origin, age and character of the crystalline schists; an able paper on the subject was presented by Dr. Lawson for the consideration of the Congress, and has been printed in the report of its proceedings.

Mr. Smith continued the preparatory topographical measurements for the Hunter Island and Seine River sheet, which are in continuation of those of the Lake of the Woods and Rainy Lake, the former published with Dr. Lawson's report in 1885, and the latter now being engraved. On this work Mr. Smith reports as follows:—

"Twelve weeks of the season were occupied in making log and compass surveys of the lakes in "Hunter's Island" and in the region north and north-east of it. As the main points of Hunter's Island had been previously fixed accurately by Mr. McAree's survey and the Minnesota township surveys, this more rapid method was deemed sufficiently accurate. The remaining four weeks of the season were employed in making a micrometer and compass survey of the Quetico Lake route from Pine Portage to the junction of the Quetico and Nameukan Rivers, tying the micrometer survey of last year, and in connecting this latter survey, at the most northerly point of Hunter's Island, with Pine Portage. Besides this, supplementary log surveys and time traverses were made in the adjacent country.

"The work involved in all about 140 miles of micrometer and compass lines, 500 miles of log and compass lines, and 60 miles of time traverses, and from points thus fixed, intermediate points and islands were determined by compass triangulation.

"The region covered extends from the provincial boundary line between the districts of Thunder Bay and Rainy River westward about 65 miles, and from the United States boundary northward about 40 miles, covering an area of about 2,600 square miles. This, with previous reliable surveys, completes the topography of the country included in the Hunter's Island sheet, and about one-fourth of that of the Seine River sheet to the north.

"This region, like all the Archæan countries of central Canada, appears rugged and hummocky, but few hills were observed over 200 feet in height above the lakes which they enclose, and soundings of the latter barely exceeded 80 feet. The numerous lakes form the most

important hydrographic feature of the country, the connecting rivers being short and broken by frequent falls or rapids.

"A very large proportion of the country has been swept by fire and few valuable timber areas are seen from the lake shores. Good farming land is of exceptional occurrence, the occasional and limited areas of drift being usually of a sandy and gravelly character.

"Nearly the whole of Hunter's Island is occupied by Laurentian gneiss and granites, with the exception of a narrow band of mica schists along the north side.

"There is also a broad band of schistose or slaty and trappean rocks containing beds of iron ore, crossing the south-eastern extremity of the island in a north-easterly direction. Dr. Lawson has not yet closely examined this band. Many mining locations have been taken up here within the last eighteen months, but no work has been done further than cutting out portages to facilitate the transport of exploratory machinery.

"To the north of Hunter's Island the gneisses are associated with mica schists, probably an eastward extension of the Coutchiching series of rocks so largely developed on Rainy Lake.

"Many of the pegmatite veins cutting the gneiss contain large crystals of beautiful white mica, which in some places may possibly be developed, of sufficient size to be of economic value."

Cost of season's work of Messrs. Lawson and Smith, $1,065.48.

Dr. R. Bell, assisted by Mr. A. E. Barlow, continued the investigation and survey commenced the previous summer (1886) between the Montreal River and the northern shores of Lake Huron, with a view to further elucidate the geological structure of the Huronian system as developed in that region, especially in connection with the copper, nickel, argentiferous galena, iron ores, gold-bearing quartz veins and other economic minerals which characterize this system, and which apparently occur at intervals in all parts of its distribution.

Dr. Bell furnishes the following summary of the work accomplished: —"I left Ottawa for the field on the 17th of July and made Sudbury, at the junction of the main line of the Canadian Pacific Railway and the Sault Ste. Marie branch, my head-quarters for the summer. Mr. Barlow and party consisting of one assistant and three canoe-men were employed most of the season in making topographical and geological surveys of a number of the lakes around Temagami Lake (which had been carefully surveyed the year before) including Cross Lake on the Temagami River. In the autumn Mr. Barlow made some geological examinations in the Township of Broder and around Lake Panache,

principally with a view to the more exact determination of the boundary between the Huronian and Laurentian systems in that direction.

"The country immediately around Sudbury, which is important on account of the gold, nickel and copper deposits now being developed there, was first examined. Then the main line of the railway was followed on foot from Mark Stay to Straight Lake; and the Sault Ste. Marie branch from Sudbury to Mississagi River, with side explorations in the township of Denison and around Algoma Mills. Onaping Lake and River, and Vermilion Lake and a part of the river of the same name were also examined.

"In 1854-56, the late Mr. Alexander Murray surveyed Wahnapitæping Lake and the Wahnapitæ River below it, as well as a chain of lakes between the former and Sturgeon River. The shores of these waters were further examined geologically by myself during the past summer. Two traverses were also made between the above lake and Vermilion River, and a track survey of about twenty miles of Wahnapitæ River, above the lake. The section of the Sturgeon River, above the part surveyed by Mr. Murray, and below the point at which I struck it in 1875, was likewise examined geologically, so that the rocks of the whole of this stream, from its source to its mouth, are now known. I next made an exploration of the southern half of Obabika Lake and part of the surrounding country, Mr. Barlow having surveyed the northern part of this sheet of water during the present season.

"A number of points requiring further investigation in connection with the geology of Temagami Lake were next attended to, and I then proceeded to Lady Evelyn Lake, which stretches the greater part of the distance between Temagami Lake and Montreal River. The track survey which I had made of this sheet of water the previous year was improved in detail, and additional facts were ascertained in regard to its geology. About seven miles west of Wendabin's house, on this lake, a mountain rises to a height of upwards of 1,100 feet above its level, and afforded some good points of view for making a rough triangulation of the region to the west of it, which has hitherto been a blank on all maps. A track survey was also made of a river from the southwest, which enters Wendabin's Bay, and of two routes between it and Nonwakaming Lake, which lies between the northern outlet of Lake Temagami and Lady Evelyn Lake.

"The work above described will enable us to complete for publication the sheet which was compiled last winter, on a scale of two miles to one inch, measuring 30 by 34 inches, and embracing Lakes Temiscaming and Temagami and a part of the Montreal River; and also one of the regular sheets, 18 by 12 inches, on the scale of four miles to one inch, belonging to the range of sheets next north of that which includes

Grand Manitoulin Island. This sheet embraces the country around Sudbury. Most of it has been surveyed into townships, and the greater number of these are now sub-divided into lots and concessions. The area which it represents is continuous with that shown on the Temagami and Temiscaming sheet.

"Geologically, these areas are occupied mostly by Huronian rocks. Whenever the boundary between the Huronian and the general Laurentian region traverses these sheets, it has been defined with sufficient accuracy. Within the outside boundaries of the Huronian, there are several detached areas of gneiss, apparently Laurentian, the limits of which were ascertained. One of these is in the townships of Denison and Creighton, and another in Snider and McKim. A gneiss area on the western side of Lake Wahnapitæping appears to be isolated as does also one on the south-west side of Lake Anima-nipissing, to the north-east of the main body of Lake Temagami. The two belts of gneiss which cross the Montreal River below the great Bend, may be connected with those to the north-east, discovered by the late Mr. McOuat, on the Blanche, but to the southward they are surrounded by Huronian strata.

"In addition to the large amount of data which was secured regarding the structure and distribution of the Huronian rocks, it is believed that the labors of the past season will throw considerable additional light on the nature and origin of these strata and the alterations which they have undergone. A large number of specimens were collected for study in the office, which, it is hoped, will develop many points of lithological interest.

"The modes of occurrence and the geological relations of the economic minerals of the districts examined were carefully studied. The metals which give most promise at present are the copper and nickel deposits which have been worked for the last three years near Sudbury.

"Early last spring the Government of Ontario having resolved to appoint a Royal Commission 'to enquire into the mineral resources of the province and the best means for their development,' did me the honor to request that I should act upon the commission, and with the approval of the Acting Minister of the Interior and of the Director of the Survey I accepted.

"Much of the data required by the Commission had already been ascertained by the Geological Survey, and my appointment resulted in greatly facilitating the enquiries of this commission, by enabling it readily to utilize whatever might be required of the vast amount of knowledge respecting the geology and tne mineral resources of Ontario, acquired by the Survey during the past forty-five years, and embodied

in the Geological Survey reports and maps, which have been published during that period, and with which I was thoroughly acquainted.

"I accompanied the other commissioners only when they were in the vicinity of the district in which my work lay, except about 13 days at the close of the season. Altogether about 50 days were occupied at intervals between July and November, in the work of the Commission."

Cost of season's exploration, $1,485.00.

Mr. A. S. Cochrane's work during the summer was in continuation of that of preceding seasons, the object being to obtain the data necessary for showing the geography of the western peninsula of Ontario, as accurately as possible, on the maps which are being prepared on the scale of four miles to one inch, to illustrate the geology of that part of the country. Respecting this work, Mr. Cochrane reports as follows:—

"I went over the ground carefully and marked in the hill features, rock exposures, positions of streams, and the natural features generally. The distances between side lines and concessions, the crossings of roads and railways, &c., were all checked by odometer measurements. The railway plans on large scales (200 and 400 feet to the inch) had all been reduced in the office during the winter, and with these on hand on the ground, I was enabled to locate all other features along them with accuracy on the map. The levels of all points which could be easily indentified on the ground and fixed on the map, such as intersections of concessions and side lines, or of these with railway lines, &c., were determined by the aneroid barometer. I had with me copies of the official plans of the original Government surveys of all the townships, and it was interesting to note the changes which have been brought about by the clearing away of the primæval forests; for example, the old plans show a large amount of swamp lands in every township. Nearly the whole of these have now disappeared, and the lands which they occupied are the most fertile in the country.

"The work of the present season was confined to the area covered by the remainder of sheet 115 (of the general scheme) which had not been finished last year, and embraced part of the township of Osprey, the whole of the townships of Artemisia, Glenelg, Euphrasia and Holland and half of that of Sullivan. This completes the field work for the above sheet, and all the material is now on hand for compiling it for the engraver.

"The cost of the season's field work was $380."

Mr. A. P. Low left Ottawa in May to continue the surveys and exploration of the eastern coasts, islands and rivers of Hudson Bay, on

which work he has now been occupied for several seasons, and though no important facts relating to the geology of this vast unexplored region have yet been elicited, considerable additions have been made to our previous knowledge of its geography and general physical character. There still remain, however, areas as large as the provinces of Ontario and Quebec, of which nothing is yet known, though there is reason to believe that, in some of these, further exploration would probably result in the discovery of valuable mineral resources and much interesting geological and geographical information.

On the work of the past summer Mr. Low reports as follows:—

"I left Ottawa on the 29th of May and proceeded by the Missinabie River to Moose Factory."

"Here the boat used the previous year was stored; in it the party sailed across the foot of James Bay, and along the east coast to Fort George at the mouth of the Big River, arriving there on the 28th of June.

"Much delay was occasioned *en route* by the large quantities of ice in the bay, which, driven by the prevailing north-west winds, at times completely blocked the way.

"From Fort George the boat was sent along the coast to meet us again at Great Whale River, and the party turned inland to make a track survey up the Big River.

"This stream was followed for forty miles with but one short portage past a small chute, twenty miles from the mouth; beyond this, the river becomes very rough and flows between such steep, rocky banks that it is impossible to portage canoes past the obstructions; a portage route to the South Branch of the Bishop Roggan River was therefore followed through several of the many small lakes which occupy one-half the area of this part of the country.

"The branch was ascended to its head, and crossing the height of land, a small stream flowing into the Big River was descended to the main stream in a large lake forming a part of the main river, one hundred miles above where we had left it.

"Again, passing up stream, still greatly broken by falls and rapids, it was finally left by a north branch sixty miles above the lake. The river here is about three hundred yards wide with a current of three miles an hour; beyond this the guide said no portages occurred for a great distance, the river flowing smoothly along the surface of the interior plateau without a distinct valley.

"Following the branch through several small lakes, a short portage was made to the headwaters of the North Branch of the Bishop Roggan River. Having passed through more lakes drained by this stream, a crossing to the South Branch of the Great Whale River was effected,

descending this river the coast was again reached after a rough trip of about three hundred and fifty miles, including eighty-four portages.

"The country along the route is an exceedingly rough plateau, having an elevation of about twelve hundred feet above the sea, swampy throughout; many low, rocky hills rising above the general level, everywhere strewn with innumerable boulders, afford evidence of great ice action.

"The whole is covered with a small growth of black spruce and tamarac, while burnt portions generally support a small second growth of aspen, poplar and banksian pine, the latter becoming rare along the Whale River. On the bottom of the Big River valley were seen a few white spruce, balsam poplar and balsam spruce, of small size, seldom or never exceeding twelve inches in diameter three feet from the ground. The rock throughout is Laurentian gneiss, a pink hornblendic variety predominating.

"Arriving at the mouth of Great Whale River, on the 26th of July, the party continued its course northward in the boat to Richmond Gulf; from the east bay of which a micrometer survey was commenced, starting with a portage of two miles past a fall of two hundred and sixty feet on a small river falling into the bay.

"This stream was followed sixteen miles, and then another portage made five hundred feet from the river valley up the surrounding hills to the plateau, and a direct route was taken through small lakes for fourteen miles to Clearwater River, which was ascended to Clearwater Lake, a total distance of sixty-three miles from Richmond Gulf. The country and rocks were found to be similar to those above described, the only trees being small, stunted black spruce and tamarac growing in clumps in sheltered parts of the valleys; everywhere else the vegetation consisted of arctic mosses, low shrubs and flowering plants, the whole having a very desolate appearance.

"Owing to the cold and wet season coming on, it was decided to proceed no farther, so the return trip was commenced on the 13th of August, and Ottawa was reached by Moose Factory and Missinabie on the 4th of October.

"Total cost of exploration, $2,034.38."

Mr. E. D. Ingall was engaged during the summer in prosecuting the investigations and surveys, commenced in 1887, but then brought to a close by an accident as stated in my last summary report, for the preparation of a monograph of the phosphate deposits. Ottawa county, P. Q., was selected as the district in which the circumstances affecting the origin, mode of occurrence, and distribution of these deposits might best be studied.

Regarding the lines upon which Mr. Ingall is conducting the work, he says:—

"The Du Lièvre phosphate district has been chosen as the one in which to study the phenomena presented by these deposits, because the greatest number of mines are in active operation there, within reasonably easy reach of each other, and therefore it is there that the features brought out from time to time by their underground development can best be observed, so that not only can the surface features be studied, but the behavior in depth of the deposits can also be followed.

"The questions, also, relating to the rock formations associated with these deposits, are of great importance, and will necessarily receive attention, and an attempt will be made to work out their nature and relationships to the deposits and to each other, as well as their distribution, and thus aid further discovery. As all these points, relating both to the deposits and their associated rocks, will require very detailed and careful study to obtain the results aimed at, it has been decided to concentrate attention on a comparatively small area, comprising about 210 square miles of country, which has been so chosen as to include all the chief mines of this district.

"The elucidation of the nature and origin of these deposits, as a guide, where and how to seek for them, is of course the chief aim of such an investigation, and as this subject has already received considerable attention by many, both amongst and outside of the officers of our Survey, it is felt that only by such detailed and careful investigation can our knowledge on these points be advanced beyond the point at which previous observers have left it. It is also evident that the value of opinions and predictions as to the probable lasting qualities of these deposits, and other things of more immediate practical bearing on the future of the phosphate mining industry, must depend upon the extent to which we understand the true nature of the deposits, and it is therefore hoped that a thorough and careful investigation may advance us, at all events a few steps, towards this desirable goal; and also that when the monograph is completed, it may be found to provide in a compact form a large amount of information, which will prove not only useful to the general public, but also render available for intending investors, mining engineers, &c., such information respecting the general features of the deposits, &c., of the district, as shall materially assist them, in forming opinions as to the value of individual deposits upon which they may be called to pass judgment.

"One of the points which has been especially kept in view in the investigation is: Whether the mode of occurrence of the phosphate is such as to render the view probable, which has been advanced by many, and has tended to check enterprise, that the deposits are confined to

surface; or whether further investigation proving them to occur, either as portions of intrusive rock masses, or in connection with such, would not rather suggest a persistency in depth for which they have not been given credit by many.

"Again, the question arises as to whether all the deposits are necessarily similar in their nature, and whether some may not be filling fissures, whilst others are more of the nature above referred to.

"On these and many other matters connected with the occurrence of phosphate deposits, a certain amount of evidence has already been collected, but, in view of the number of very contradictory theories already advanced at various times, it is felt that it would be wiser to reserve any expression of opinion until the further study it is proposed to make shall give a sufficiently broad basis of fact upon which reliable conclusions may be founded, rather than to venture any premature suggestions or theories which would only be adding to the already too large stock of ill-based speculations on this subject."

In carrying on this work, Mr. Ingall has been assisted by Mr. James White, whose time has been taken up in conducting the topographical measurements necessary for the construction of a map of the area under study, on such a scale, that the details of the distribution and association of the different rocks may be delineated thereon.

Of the 210 square miles comprised, as stated, within the limits of this map, the lakes, rivers, roads, &c., over some 125 square miles have already been surveyed, leaving about 85 square miles to be done next season, when it is hoped to complete the work. These surveys have been plotted on a scale of 40 chains to the inch, and it is proposed to publish plans of special areas immediately surrounding the chief mines, on a scale of 200 feet to an inch, which will form the basis of special studies around these points. With a view to get a general idea of the geological features of the district under study, all the roads in the area, upwards of 200 miles, were travelled over and the outcrops examined. The rest of the season was taken up in commencing the special studies of the phenomena presented by the chief mining experiments, and in visiting the various mines from time to time to ascertain whether any new features had been brought out during their development. It will not be advisable to attempt to give a detailed report on the district till after another season's investigation has been completed.

Cost of season's exploration, $1,289.78.

For about two months and a half during the past summer, Mr. F. Adams continued explorations in the counties of Joliette, Berthier, Maskinongé and St. Maurice, in the province of Quebec, with a view to securing additional data for the north-west sheet of the Eastern Town-

ships map. The south-east sheet of this map was completed and published last year, and the north-east sheet is now surveyed and will be ready for publication in the spring: each of these sheets covers an area of 4500 square miles, represented on scale of 4 miles to one inch, or natural scale of $\frac{1}{253440}$. This season Mr. Adams examined an area of about 1,500 square miles, embracing a part of the Mattawin River and its tributaries, the headwaters of the River du Loup and such portions of the country to the south of these as had not already been examined. On this work Mr. Adams reports as follows:—

"All the northern portion of this district consists of Laurentian gneiss interstratified in places with thin bands of crystalline limestone. On the Cypress River, River du Milieu and on the Mattawin, to the west of the Ile de France, these gneisses dip at rather high angles to the west or south, but to the east of the Ile de France and on the headwaters of the River du Loup, they are flat or nearly so.

"In the southern portion of this district, especially in the township of Brandon, there are many intercalations of various varieties of anorthosite in the gneisses, which latter dip at rather low angles either to the east or west. All the areas of anorthosite now known to occur in the district have been examined, and mapped, and have proved to be either eruptive masses cutting through the gneisses, or masses interstratified with the latter, but probably still of eruptive origin. In the north-east corner of the district is a large mass of very coarse-grained basic red granite, which has already been mapped by Mr. McConnell. All localities where minerals of economic importance were known to occur, especially mica deposits, were visited and examined. Several supposed occurrences of gold were also examined and specimens collected, which have not as yet been assayed. One of these veins, near St. Alphonse, which was worked several years ago and abandoned, has recently been re-opened, and is now been worked to a considerable extent. The rock consists of a band or vein of crystalline limestone about 3 feet wide, flanked on either side by quartzose grey gneiss. The latter has been assayed in Chicago and is said to be rich in gold. Samples were taken for assay. A report on the district is now being written.

"I returned from the field on 5th November.

"Cost of season's exploration, \$378.79."

Dr. R. Ells, assisted by Mr. N. J. Giroux, has, during the past summer, continued and extended the re-examination of the complicated geological structure in the valley of the St. Lawrence; on the south side, from Point aux Plateau, about 40 miles above Quebec, to River du Loup, and on the north side, from the mouth of Jacques Cartier

River to the vicinity of Cape Tourmente, including also Orleans and Crane islands and the other islands in the river between these. Several hundred miles of roads in the country on the south side were surveyed, and sections were made on the Etchemin and Bécancour rivers of 30 miles each. The report of this work, giving in detail the facts observed and the conclusions arrived at, will be prepared to accompany the north-east ¼ of the Eastern Townships map, when the measurements have been plotted, the observations studied, and the numerous fossils collected have been examined. The result will be to very greatly modify the geological mapping of a large part of this region, especially that of the south shore below Quebec, as published in the Report of the Geological Survey, 1869. It has now become more than ever plain that the Lauzon and Sillery slates and sandstones are not above but below, and older than the Levis formation; and that no such divisions as are indicated on the map accompanying the report referred to can be recognized on the south shore below Quebec.

The gold districts of the Chaudière and the asbestus mines of Thetford, Coleraine, &c., were also visited, for the purpose of noting the development during the year, and ascertaining the yield from the different mines. On this subject Dr. Ells has furnished the following report, which, as being of more immediate interest and practical importance, is given in full:—

"The principal mining industries in the area examined by us are gold and asbestus. The former has been prosecuted more vigorously than in the previous year, four companies operating in the Chaudière district, viz., The Horace Sewell Co. on the DesPlantes, McArthur and Coupal at St. Francis, Capt. Richards on the Cumberland, and St. Onge Bros. on the Famine. All of these are supposed to be working in old river channels. The DesPlantes works consist of a shaft 30 feet deep, about 60 feet east of the stream and half a mile north of the bridge, near the mouth, at which spot a bed of well washed river gravel was struck, cemented by clay and resting upon altered slates and sandstone with diorites; coarse gold in good paying quantity is taken from this spot, though the high water in the river during the autumn interfered seriously with the work. At the time of my visit, but four men besides the foreman, Mr. Fenton, were employed. The bed of the DesPlantes at one time yielded a large amount of coarse gold.

"The most extensive workings in the district are now carried on at the Ruisseau Meul, a branch of the Millbrook, near St. Francis Village. A tunnel has been driven into the hill to a distance of 600 feet, in an old channel which at 400 feet was 30 feet below the adjoining bed of the brook, from which it was separated by slate reefs. The gravel of the old channel has yielded considerable coarse gold, nuggets from $5

to $15 value having been taken out during the past season. Drifting near the upper end of the tunnel is now being carried on, but much difficulty is experienced from quicksand. Neither here nor at the Des Plantes are there any appliances suitable for saving fine gold, and some changes in this respect will be necessary before satisfactory results will be obtained. From twelve to fourteen men were employed during the past season.

"Captain Richard's work on the Cumberland is yet largely exploratory, and no returns of gold taken out are to hand. Difficulty from quicksand is experienced here also in sinking shafts. No mining has been done on the Gilbert year, but on the Famine the St. Onge Bros. have driven in the east bank, about a mile above the road across the mouth, for several hundred feet in what they claim to be an old channel of that stream, and gold has been taken out in small quantity. The old workings on Slate Creek have been abandoned.

"The asbestus industry of Thetford and Coleraine continues to rapidly increase in importance. The formation of the new Bell Company of London during the past season, by which detached areas have been brought under one management, and the wonderful advance in the stock has incited fresh explorations, and several new openings have been started. Prospecting has been active during the past season, not only in Thetford and Coleraine, but in the great serpentine area of Wolfestown, and good indications of asbestus have been found at several new points. But the largest quantity and the best quality of fibre continues to be derived from the Thetford mines, though the very bad season of 1888 has reduced the output very seriously. The asbestus at these mines differ very materially from the greater part of that obtained at other points, both in Broughton on the one hand, and in Coleraine on the other. That from Coleraine and Wolfe is to a certain extent affected by a harshness and stiffness which pertains to a very considerable portion of the output, rendering the percentage of *firsts* much less than at Thetford. The fibre is also for the most part shorter, and much of it, especially near the surface, is discolored, probably from the percolation of surface waters charged with iron.

"Although large areas of serpentine exist at various points in the townships above named, a great part of them are, in so far as explorations have extended, apparently devoid of profitable veins of good asbestus; in some, short fibred veins of harsh and brittle mineral are found, but these have as yet no economic value, so that the really valuable areas are not very numerous. During the past season all the old mines were carefully examined as well as the new openings being made during the year. Among these last may be mentioned the Megantic Mine, one mile and a half from Coleraine station, first prospected in

1886, but now worked by Fenwick & Slater, of Montreal. A peculiarity of this mine, not noticed elsewhere so far, is the occurrence of considerable quantities of mica in veins with impure asbestus. The rock here is very much shattered near the surface, and the fibre is consequently discolored. Veins up to one inch and a half are found, and in the more solid portions the quality improves. The output from this place has been necessarily small, owing to the time spent in opening the mine, and the delays from bad weather; the quantity mined in four months to October 1st, being 39 tons, of which one-third may be classed as *seconds*, the rest as *thirds*. An average number of twelve men was employed.

"Near Black Lake several openings have been made along the track of the Quebec Central Railway, by Messrs. Johnston & Lomas. Only three to four men were employed, and the work was of a preparatory nature. The quantity of asbestus obtained was not stated. On lot 32, range B, Coleraine, work has been begun by Capt. Williams. At my visit in October, the average number of men employed was 15, and the output to date 29 tons, of which 4½ tons were *firsts*, the rest about equally divided between *seconds* and *thirds*.

"In this district also the Bell Company began operations on the north half of lot 28, same range, formerly the Hayden property. Very good surface indications are here visible, many small veins showing, while in the cut now going in towards the base of the hill, fibre an inch and a half to two inches long of good quality is found. The south half of these lots 28 and 27, belonging to Dr. Reid, has lately been sold to the Wertheims of Frankfort, Germany, who are putting in machinery preparatory to developing the mine. This property is the most elevated of any in the district, being not far from 600 feet above Black Lake Station. The surface indications are here very favorable, veins up to two inches and a half having been found. Prior to the sale about twelve tons were taken from this place, of which two tons were *firsts*, four *seconds*, and six *thirds*. It is now being worked by contract at $25 per ton, ready for the market. On the north side of the Poudrier Road, in lots 27, 22, 29, range A, Coleraine, several openings have been made and good indications have been obtained. At the time of my last visit, veins of asbestus up to an inch and a half were seen with a number of smaller ones. On lot 26, also, an opening in the surface of the hill disclosed small veins. These areas are separated from those of Black Lake proper by masses of white granulite and dioritic rock, a belt of which, closely associated with the serpentine, extends from the shores of Black Lake to the rear of the Thetford mines.

"In the township of Ireland, on the west side of the great serpentine area, which extends north-east from Wolfestown, King Bros. have

started two openings on lot 24, 25, range III. The elevation of these by aneroid is about 500 feet above the surface of Black Lake, which is 200 feet below Thetford station on the Quebec Central Railway. The asbestus here is found principally in two knolls about one-fourth of a mile apart, and occurs at times in a series of thin veins from one-eighth of an inch upward, as many as twenty being sometimes found in a space of six inches. Many of these veins show a selvage of whitish weathering serpentine on either side, separated by a thin vein of asbestus from $\frac{1}{4}$ to $\frac{3}{8}$ of an inch thick. Other veins of greater size are numerous, ranging in thickness to $1\frac{3}{4}$ inches; the aspect of the rock and the veins at this place strongly resemble in many respects those on the Belmina property in Wolfestown. The surface indications in so far as visible are excellent, but the mine has not been thoroughly opened, only two months work with a small force having been spent on it.

"At Thetford, new openings have been made to the west of the Quebec Central Railway by Messrs. Ward Bros., by Mr. Johnston and by King Bros. These prove to a certain extent the serpentine area between the present workings and the Thetford River, and good indications of productive ground are found at all the locations, though the lower lying level of the ground may necessitate drainage works.

"On lot 28, range VI, Thetford, good indications are found, as also on lot 32, R. C. Coleman, but no work has been done on either of these during the past year. Further north, on lots 16, 17 and 18, in range IV, Thetford, a belt of serpentine occurs which has been opened by Dr. Reid, who reports some very good veins of asbestus. Chromic iron, also, is found in this area, but the samples seen by us seemed too poor in chrome to reach the required standard. Noses of serpentine also occur on lot 13 range V, and on range XI, Broughton, from which asbestus has been reported, but, in so far as yet learned not in such quantity as to be economically valuable. The Broughton mine was also worked during the past season; the vein, of which there appears to be only one, in places reaches a thickness of 3 inches; at others it is split up into a number of thin strings of no value. The returns from this mine, have not been received.

"The established mines in all the districts have been working during the past year, though the output has been greatly lessened by the very bad weather, especially during the autumn months. An attempt to obtain the output from each mine has been made, but has been only partially successful, several of the managers neglecting to forward the requisite information in time. Of the Thetford Mines, the output of the Bell Company mine, formerly the Boston Company, still far exceeds the others. The shipments for the season to 1st December being

1,350 tons, of which 930 tons were *firsts*, 105 tons *seconds*, and the rest waste or *thirds*, The quality of the asbestus from all the mines of this district is excellent, and the prices obtained are even higher than quoted in the report of 1886; *seconds* in some cases commanding $75 per ton and *firsts* from $80 to $110. The output from King Bros.' mine for 1888 was *firsts*, 170 tons; *seconds*, 165 tons; *thirds*, 245 tons. Average number of men employed, 32; boys, 20. The returns from the other properties are not yet in, but there has been great activity in them all, and the output has been correspondingly large. Rock drills worked by compressed air have recently been introduced at the Bell mine.

"In the Black Lake district the principal mines in operation are the Scottish-Canadian, the Anglo-Canadian and the D'Auville. Mr. Penhale, the manager of the Scottish-Canadian, states that in the eight months ending 10th November, 400 tons were shipped from that mine, of which 40 tons were *firsts*, 110 tons *seconds*, and 250 tons *thirds*, but operations were hindered by scarcity of men and bad weather, so that the new workings could not be carried on. This mine is equipped with improved machinery, air compressor, rock drills, hoisting engines and dumping skips, with a new set of appliances for crushing the rock and separating the asbestus, more particularly in regard to the lower grades, to avoid the great expense of cobbing by hand. This machine was in operation but a short time, but is claimed by the manager to be a great success. Should this be the case, and the asbestus of short fibre be easily separated, it will largely enhance the profits of the industry, since many of the dumps, most of which now cover very valuable ground, can be profitably worked over and the refuse disposed of for ballasting or other puposes, while, under the present system of hand-cobbing, the shorter veins do not warrant the expense necessary for their separation. The Anglo-Canadian mine for the six months ending 15th November produced, according to Mr. Hopper, about 210 tons, the average number of hands, including cobbers, being 30 to 35. The principal pit at the mine has been sunk to a considerable depth, and Mr. Hopper reports veins at the bottom of very superior asbestus, resembling that from Thetford, from 3 to 7 inches thick. These veins have been uncovered since my visit. The percentage of *firsts* from this mine has, according to the manager, increased from 10 to nearly 20 per cent. Openings in the face of the knoll to the west of the principal pit are now being worked, the indications here being very good. The output of the Fréchette or D'Auville mine, which lies between the two just mentioned, is given by Mr. Hopper for the season to 1st December as about 300 tons.

"The cause of the difference in quality between a great part of the

output from the Black Lake mines and those of Thetford has long been a source of enquiry to the mine owners of those places. By some it is supposed to be due to the difference in level between the two places, the works of the Scottish-Canadian Company being from 250 to 300 feet higher than those of Thetford. Yet this can hardly be taken as satisfactory, since at the Reid mine, 300 feet higher, some excellent fibre is found. A more likely reason may possibly be the driving off of the contained water in the fibre, since asbestus is a hydrous silicate of magnesia, by the action of diorites or the metamorphism proceeding from the presence of the granites, which occupy a considerable area in the Black Lake district. If the soft silky fibre is heated it changes its character at once and becomes harsh and brittle. The serpentine near the contact with the granitic veins or masses is often very considerably shattered, as though the presence of the granite had exercised a marked influence on its condition. At Thetford the granite masses in the mines are limited to small and thin dyke-like veins, which have not produced any great effect upon the asbestus. It must, however, be said that the stiff-fibred mineral is not in all cases confined to the vicinity of visible granitic masses, and other causes may in such cases have produced a similar effect.

" A map of the asbestus region has been compiled from crown lands plans and our own surveys, using the survey of the Quebec Central Railway which has been furnished us from the Department of Public Works, Quebec, as a base line. All the mines have been indicated on it, both the old and the new openings, and it is hoped it will be of use to those interested in the asbestus mining industry. It is proposed to publish it with the detailed report on the district.

" The season's work extended from 31st of May to 29th of October.

" Amount expended, $1,100.

" My assistant throughout was Mr. N. J. Giroux, C. E., P. L. S.

Professor J. W. Bailey, with Mr. McInnes, continued the survey and exploration in northern New Brunswick, and now furnishes the following statement respecting this work, from which it will be seen that only two ¼ sheet maps now remain to complete the general geological map of New Brunswick, the whole of which has been published on a uniform scale of four miles to one inch in consecutive ¼ sheets :—

" One main object of the several explorations was the obtaining of the necessary data for the completion of sheets 17 N.E. and 18 S.E. of the New Brunswick series of maps, being the last two illustrative of the geology of that province. Particulars of this work, which was chiefly carried on by Mr. McInnes, are given below.

"My own attention was more especially directed towards completing the observations, referred to in former reports, regarding the order of succession, equivalence and similar features, of the Silurian system as developed in northern New Brunswick, Quebec and Maine. With this object in view, and that the means might be had, of more directly comparing the Silurian rocks above the headwaters of the St. John River with those of the Gaspé Peninsula, the section afforded by the Metapedia Lake and River was first examined and further collections of fossils made.

"Attempts were then made to explore the somewhat prominent range of hills, forming a portion of the Notre Dame Mountains, which lie a few miles to the westward of Lake Metapedia, and which, from their altitude and comparative boldness of outline, had been regarded as probably containing Pre-Silurian strata, but these, as well as subsequent explorations by Mr. McInnes, failed to afford any evidence of the existence here of other than Silurian rocks.

"It was then proposed to make a revision of the section afforded by the Patapedia and Grand Metis Rivers (see Geology of Canada, p. 416) but the want of water when we were at work in this section prevented this being done. An exploration was, however, made of the Misguegogish, one of the chief tributaries of the Grand Metis, to within a mile or so of its source, and information was thus obtained regarding an extensive district of which but little was previously known. From the Grand Metis the northern edge of the Silurian plateau was carefully traced around, by way of Mount Commis and the Neigette River to Bois Brulé Mountain and St. Blandine near Rimouski. At several points, and especially at the last named, large and important collections of fossils were secured.

"The examination of the country lying between the Rimouski and Lake Temiscouata was then undertaken by Mr. McInnes, and my attention was next directed, in company with that gentleman, to the examination of the admirable section of the so-called Quebec group between Lake Temiscouata and Rivière du Loup, afforded by the newly made cuttings of the Temiscouata Railway. These were found to be largely through the rocks of the Sillery formation, alternating in a succession of folds with bright red and green slates, but we failed to find any fossils, though they were carefully searched for.

"Other work undertaken consisted of the exploration of the country bordering and lying between Pohenogamook Lake and Cabano Lake, of that lying between the eastern and western branches of Fish River, in northern Maine; the ascent of the Aroostook River to the Oxbow Plantations, and the examination of the country in the vicinity of Presqu'île. A visit was also made to the locality north of Frederic-

ton, in which obscure fossils had been found in rocks not previously known to contain organic remains.

" The results of these explorations will be given in detail in the report now in course of preparation.

" In addition to the work above described, the following surveys were made during the season by Mr. McInnes.

" Early in July a micrometer and paced survey was carried across the height of land south of the St. Lawrence, by way of the Quatawamkedgwick and Rimouski rivers. These two streams head quite close together; lakes at the sources of their right and left hand branches respectively are separated only by a low ridge, crossed by a portage 1,536 paces in length. Rocks of supposed Silurian age were found te extend from the Bois Brulé escarpment, nine miles back from the St. Lawrence at Rimouski, over the whole area traversed between that point and the St. John River. Grey calcareous slates, generally banded with more highly calcareous layers, are repeated again and again in a series of folds running roughly at right angles to the general course of the rivers followed. Hard siliceous sandstone, forming the crests of anticlinal folds along the main Rimouski River, seem to be the lowest members of this series. At one point just north of the Provincial boundary line, the strata were found to be fossiliferous, and a small collection was made, which will be further treated of in the extended report.

" Another traverse was made across this watershed by the Trois Pistoles, Boisbouscaché and Tuladi rivers. Here the older rocks (Cambro-Silurian) cover a much broader area; and slates and sandstones, thought to represent the Levis and Sillery formations extend southwards as far as Lac des Iles; beyond this point banded slates, similar to those along the upper part of Temiscouata Lake, were the only rocks seen.

" A survey, partly with micrometer telescope and partly paced, was made through the country lying between the St. John River and Temiscouata Lake. The route taken followed up Baker Brook to the lakes at its head, and thence by a portage of about four miles led to Long Lake which is drained by the Cabano River into Temiscouata Lake; this traverse was wholly within the Silurian area.

" During the season about 220 miles of lakes and streams were surveyed with the micrometer telescope and by pacing, and traverses were made of other streams of which surveys were alrealy available.

" The field work occupied from 28th of June to the 16th November, and the expenditure was $1,816.47."

Mr. R. Chalmers having been occupied during the early part of the year in the preparation of the report and maps relating to the work of 1887, left Ottawa on the 1st of June with instructions to continue the detailed examination and mapping of the surface deposits of southern New Brunswick, the special field of work being the area embraced in the geological ¼ sheet No. 1, N.E. Mr. A. H. Beers, of Montreal, joined Mr. Chalmers at Moncton as volunteer assistant. The work performed is summarized by Mr. Chalmers as follows :—

" Commencing in the north-eastern part of the district we proceeded to examine it south-westwardly on both sides of the Intercolonial Railway as far as Sussex, which we made our headquarters for some weeks. Thence we traversed the surrounding country in all directions and made a large number of interesting notes. On the 18th July we proceeded to St. John and engaged a man and boat with the view of exploring the lower part of the St. John River valley, including Belleisle Bay, Washadamoak and Grand Lakes, &c. This occupied our time till 11th August. Returning to Sussex, we then started to examine the country to the south and south-west as far as Hampton. On the 27th August Mr. Beers left for home. I then commenced the exploration of the elevated tract in eastern King's and southern Albert, and the country bordering the Bay of Fundy. The frequent rains of September, October and November greatly hindered field operations, however, and although a considerable portion of the district referred to was traversed, I was unable to complete the work of the season as I desired. In November I visited Nova Scotia, making some observations on the dispersion of boulders from the Cobequid Mountains, &c., which are of interest when correlated with the facts respecting boulder distribution in New Brunswick. The unfavorable weather continuing, before closing field work, I proceeded to Restigouche a day or two to examine some more deposits which have just been opened up.

" The work of the season has been, on the whole, interesting, and a number of new facts were discovered. Evidences of Post-Tertiary ice action are abundant in most places, but the courses of striæ are somewhat diverse. The higher grounds which occupy the southern part of the district, and near the Bay of Fundy, form a plateau, ice movement and drift-transportation being southward or south eastward towards the coast. In the interior along the longitudinal valleys which lie parallel to the coast, the striæ conform in a greater or less degree to these. In the north-western half of the area included in the map, where the country is low and flat not exceeding 300 to 350 feet in height, the general direction is south to south-east; while in the tract drained by the Petitcodiac River and its tributaries the ice followed the general north-eastward slope. In many places two or more sets of

striæ are recorded upon the same rock surface. The erosion from ice appears to have been slight, judging from the great masses of decomposed rock undisturbed, and from the number of unglaciated areas. In some basin-shaped valleys in the interior, the ice seems to have been motionless, or nearly so, and to have produced striæ around their borders simply by expansion.

"Decomposed rock and till constitute the great bulk of the superficial covering on hill summits and slopes, as well as on the larger part of the flat Carboniferous area. The thicker masses of till generally exhibit a rude stratification or bedding. Near St. John, lenticular masses of stratified clay occur in the till. One of these apparently occupies the bottom of a bank of till 15 to 20 feet in thickness. At Alma, well exposed sections show what have been called "upper" and "lower" till. But the two are really only one deposit, the upper part of which having undergone oxidation from exposure to the atmosphere for a long time, has assumed a yellowish or brown color. The oxidized portion seems, however, to contain less clayey material than the underlying bluish grey till. The whole deposit is made up of the débris of the underlying rocks.

"A considerable amount of data relative to lake basins, the origin of lakes, &c., were obtained. The lakes connected with the lower St. John are on the same level as its waters and are consequently tidal. All these are merely bodies of water ponded back by the narrowness of the St. John at its mouth, and by the obstruction which the tides, when at their flow, offer to the exit of its waters. Grand and Washadamoak Lakes and Belleisle Bay occupy the lower parts of the old valleys of the streams which now flow into their northern extremities. A rise of the land of 175 to 200 feet would enable the St. John to drain out its lower reaches and also these lakes.

"Several basins of extinct Post-Tertiary lakes were observed, notably Sussex Vale. Such of these as occur below the 200 feet level probably had only a brief existence. They originated as the land rose out of the sea, and before the present drainage channels had become established. As soon as the streams passing through them had sufficient time to cut down their outlets these lakes disappeared.

"Stratified gravel, sand and clay are abundant in all the valleys, more especially upon the Carboniferous rocks. The valley along which the Intercolonial Railway runs from Moncton to St. John is terraced with gravel and sand almost throughout its entire length. This valley, was, during the Post-Tertiary subsidence, a strait, and the highland tract between it and the Bay of Fundy was then an island. The terraces both in this valley and on the coast indicate a Post-Tertiary depression of the land of about 200 feet below its present level.

"Dyked salt marshes extend along the Petitcodiac valley and also skirt the coast at Little Rocher. Extensive fresh water flats occur along the St. John, forming all the islands and also wide intervals in parts of the valley. Others occur along the Kennebekasis, Petitcodiac, &c. They are nearly all under cultivation.

"Large portions of the area included in the map are still forest-clad, the northern area being entirely so. In eastern King's and Albert counties considerable tracts also are still covered by the original forest. The central and south-western parts of the district are extensively cleared.

"The agricultural character of the district is varied, depending in each locality largely upon the nature of the underlying rock. On the higher grounds near the coast the soil is stony and clayey; on the Carboniferous, gravelly and sandy, &c. The best land is in the valleys, more especially where lower Carboniferous rocks prevail, and along river banks and the margins of lakes. The country through which the Intercolonial Railway runs contains some excellent, well-cultivated farms. Sussex Vale is frequently called the garden of south-eastern New Brunswick.

"The materials of economic importance observed are infusorial earth at Pollett Lake, King's county, and Fitzgerald Lake, St. John county, referred to in previous reports. Brine springs occur near Sussex, and along Salt Springs Creek. At the former salt for dairy use has been prepared for a number of years. Clay and sand suitable for brick-making, &c., are abundant in many parts of the district.

"In November a short time was spent examining the glacial phenomena and drift deposits of the Cobequid Mountains and adjacent country in Nova Scotia by way of comparison with those of a like character in southern New Brunswick. It was found that the boulders had been transported in both directions from these mountains, *i. e.*, northward and southward. No striæ were observed, but transportation would seem to have been effected chiefly by ice, but to some extent also by the force of running water and gravitation. One fact especially noticeable is that boulders derived from the mountains become smaller and scarcer as we recede from them.

"On the 30th November I left the field for Ottawa."

Cost of session's exploration was $845.91.

Mr. H. Fletcher left Ottawa on the 5th of June for Nova Scotia to continue the work in Pictou and Colchester counties, especially in view of making the additions and alterations referred to in the summary report of last year, as being now required in the map of Pictou coal fields as

published in 1869 by Sir W. E. Logan. This work was partly accomplished during the past year, as well as the survey of the western part of Pictou county and the eastern part of Colchester, required for completion of the geological maps of these counties. Respecting this work Mr. Fletcher reports as follows:—

"Along the northern part of Pictou and Colchester counties, from Big Island, Merigomish to Brulé and Tatamagouche, there is a wide belt of rocks described in the Annual Report, Geological Survey, Vol. 11, Part P., the conglomerate at the base forming Fraser's Mountains, Greenhill, Roger's Hill, Fitzpatrick Mountain, Dalhousie Mountain, the Biorachin and other high lands on its course. This conglomerate is overlaid by a great thickness of red shales and sandstones, these by grey and greenish sandstones from which good building stone and grindstones are quarried.

"Below these strata come the measures of the Pictou coal field, the limits of which were accurately determined by Sir William Logan and Mr. Hartley in 1869. Beneath them, in the eastern part of the district, are lower Carboniferous, Devonian, Silurian and Cambro-Silurian rocks; west of the East River of Pictou, only Lower Carboniferous and Devonian; while on approaching the eastern spurs of the Cobequid Hills, Silurian, Cambro-Silurian and Pre-Cambrian (?) strata are again found.

"Six collieries are in operation in the Pictou coal field, the Vale, East River, Albion, Acadia, Intercolonial (Drummond) and Nova Scotia (Black Diamond), having an aggregate annual yield of about 400,000 tons of coal. It has been supposed that the Permian rocks lying north of this field which hold plants and erect and prostrate tree stems, also include workable coal seams, and many boreholes have been put down to test these measures. The principal of these are: two near Pictou, 667 and 400 ft. deep; one at Logan's tannery, 1,000 ft.; two at Lyon's Brook, 500 ft.; one at Hardwood Hill, 700 ft.; three on Cari boo Island, 500 ft.; one on the East River, 750 ft. Only eight small seams of coal have, however, been cut on Cariboo Island, at the mouth of the Cariboo River, on the East River below New Glasgow, near the mouth of the Middle River and elsewhere, ranging from two feet downward and resembling and perhaps equivalent to, the small seams of Merigomish Island, Little Harbor, Small's Brook and Fraser's Mountain.

"Numerous attempts have at various times been made to work the rich grey sulphides and green carbonates of copper which are found in this formation in layers with lignite, pieces of jet, barytes, calcspar and other minerals impregnating large fossil tree trunks or in concretions; but none of them have proved successful, because the ores,

though containing sometimes 40 per cent. of copper, are not in workable quantity. The best known localities where these ores occur are on the banks of the Cariboo River, eight miles from Pictou, Toney River, at Durham on the West River; Scotch Hill; in Scotsburn Brook about 400 yards above the bridge at the church; and at River John. In the lower rocks traces of copper are found at Hopewell; on the East River; and on the Middle River near the mouth of McCulloch Brook.

"From the Permian formation valuable materials for building, grindstones and millstones are derived. From the Acadia quarries at Sawmill Brooks, West River, 1,200 tons of culvert and building stone were taken in 1888 by Mr. R. E. Chambers, and from the Granton quarry 350 tons of building and monumental stone, shipped principally to Halifax, and 110 tons of grindstone sent to Boston. The quarries at Pictou and at the Four, Six and Eight Mile Brooks of the West River also produced a large quantity of stone. Limestone fit for burning is found at Cape John, Cariboo, River John, Valley and elsewhere. Gypsum of good quality occurs in the neighborhood of Valley, and in very small quantity at Cape St. John. Barytes was exported from River John and from Brookfield, and is known to occur also at other points within the region examined.

"At Brookfield an important deposit of limonite has been opened by Mr. Chambers, and 1,000 tons extracted for shipment to Londonderry Mines. Limonite is also found at upper Stewiacke, and a promising deposit of red hematite at Newton Mills. The iron ore of Bridgeville has been largely worked during the summer of 1888 for transportation to Londonderry.

"A small seam of gold occurs in rocks underlying the Carboniferous limestone and has been opened near West River station at Riversdale, Salmon River, and the North River of Onslow, but is apparently nowhere of workable size and quality.

"At Manganese mines, near Valley, a quantity of black oxide of manganese is found in irregular veins, cutting a reddish slaty rock which underlies Carboniferous limestone.

"At Pembroke, Colchester county, galena, disseminated in a large mass of Carboniferous limestone and not in a definite vein, was unsuccessfully worked before 1877. At Smithfield a large body of sulphides of lead and iron was discovered in similar limestone at its contact with the underlying slates. Assays showed 100 ounces of silver to the ton of lead, and 5 dwts. of gold to the ton of ore. The property has attracted a good deal of attention, and it seems probable that, if the ore is in sufficient quantity, it may be profitably developed. In 1884, 100 tons averaging about 40 per cent. of lead were taken out, a small smelter erected and the ore successfully roasted in calciners.

"Several brickyards lie within the area surveyed and have long been in operation. A new one, lately established at the railway station of Sylvester, on an excellent deposit of clay, is capable of supplying a large demand for bricks.

"Deposits of infusorial earth are known to occur in the bottom of some of the lakes. But as the attempt to utilize the similar deposits at Folly Lake and at St. Anne's, in Cape Breton, have not been successful, nothing has yet been done to develop them.

"Through the kindness of Mr. S. H. Poole, manager of the Acadia Company's collieries, and of Mr. Robert Simpson, manager of the Intercolonial colliery, and of Messrs. Harvey, Graham and John Sutherland, of the Nova Scotia mines, valuable plans were obtained of underground and surface surveys, and around the Pictou coal fields, and much information regarding certain parts was given by Mr. Poole, Mr. Alex. McBean, Mr. James Maxwell, Mr. Fergie, Mr. R. P. Fraser and others."

Mr. Fletcher returned to Ottawa on 22nd December. The cost of the season's exploration, including salary of assistants, was about $700.

Mr. E. R. Faribault left Ottawa on the 31st May, to continue the examination and survey of the gold-bearing rocks of the Atlantic coast in Halifax county. He reports on this work as follows:—

"The district surveyed lies westward of that surveyed in 1887. It comprises the country watered by the two Little West rivers of Sheet Harbor and the Mushaboon, Tangier and Sheet Harbour rivers, an area of some 360 square miles.

"The sharp east and west folds into which these rocks were plicated to the eastward are found here again to continue their course is a westerly (magnetic) direction. They were traced with all possible accuracy, and the relation of the auriferous belts to the anticlinals has been carefully studied.

"The result of the work cannot yet be given in detail; but it may be safely stated in the interest of the mining community, that auriferous belts in Nova Scotia should be looked for only on or near to the anticlinal folds, and more especially on sharp ones. Hence the importance of accurately tracing and mapping these anticlinals to guide the prospector in the discovery of new auriferous belts, and thus prevent, if possible, the expenditure of thousands of dollars annually wasted in prospecting non-auriferous belts, because a few "sights" of gold, probably drifted from a distance, have been found in the vicinity. This consideration led me to devote two weeks last season in re-examining

the interior of the country, which is watered by the Sheet Harbour rivers, with the view of tracing out more accurately and studying more closely the various anticlinals affecting the strata.

"Four gold mining districts are now being worked in the region surveyed and examined: Tangier, Mooseland, Moose River and Caribou. In every one of these the auriferous leads are worked on each side of the anticlinal axes, and in no case are they more than 400 feet from them."

The country underlaid by these rocks and extending from Cape Canso to longitude 62° 19', has been mapped on the scale of one mile to an inch, and is now waiting publication. This map covers eight sheets of 12 by 18 inches, and three more will be ready by next spring.

Mr. Faribault was assisted during the whole season by Messrs. John McMillan and A. Cameron, and part of the season by Messrs. A. P. Faribault and Jas. McG. Cruikshank.

Field work continued to the 1st of October, and the expenditure in connection with it amounted to $1.025.

MINERAL STATISTICS.

Mr. Coste was engaged during the winter and the spring, assisted by Mr. Brumell, in preparing the report on the mining and mineral statistics of Canada for 1887. About 3,000 printed forms for returns of mineral production had been distributed, and later, about 3,000 letters were sent urging the transmission of the returns and seeking further information. Shortly after the close of the year, 1,500 returns and replies to letters had been received, and the full report was printed and issued in September last, and will form Part S. of Vol. III, Annual Report, 1887-88.

At intervals during the summer, Mr. Coste or Mr. Brumell visited a number of localities in Ontario and Quebec, with a view to investigate the occurrence of natural gas and petroleum in those provinces, especially in the formations that underlie the Devonian. In reference to natural gas Mr. Coste states as follows:—"A number of localities where natural gas had been reported were examined, and where possible the gas flow was measured and the logs of the borings and specimens of the drillings were obtained. Respecting wells bored several years ago, it was impossible to obtain any reliable information, and the loss of all such valuable data is very much to be regretted. The result of our investigation is that none of the wells yet bored in Ontario and Quebec produce more than 50,000 cubic feet of gas per diem, and very few even this much. The production of these wells, though small as compared with those of the United States gas region, are nevertheless of some value when in or near towns or villages."

"There seems no reason why further trials, especially in that part of Ontario between Lake St. Clair on the south-west and Lake Simcoe on the north-east, should not prove more successful, and yield as abundant a supply of gas or petroleum as do some of the Ohio wells."

In reference to petroleum, Mr. Coste states that no new oil wells of value have been bored, and that the entire production, 594,273 barrels in 1887, is confined to the county of Lambton and produced from about 2.700 wells, very few of which yield more than one barrel per diem. The average depth of the oil rock in Lambton is 490 to 500 feet from the surface.

Several wells have been bored in Essex county. One at Comber, 1,300 feet deep, is said to yield about one barrel of oil per diem. This oil is probably from the same formation as that of Findley in Ohio.

CHEMISTRY AND MINERALOGY.

The work carried out in the chemical laboratory during the past year has been entirely confined to the examination and analysis of such minerals and specimens, as were deemed likely to prove of economic value. Respecting this work Mr. Hoffmann gives the following e ai s :

"It included:—

1. Analyses of lignitic coals.

2. Analyses of iron, copper, and manganese ores.

3. "Analyses of mineral waters—including analyses of the waters of the so-called "sulphur" and "potash" springs, Harrison Hot Springs, B. C., which were collected by Dr. Selwyn; analysis of a saline water from a boring at Otonabee, Peterborough county, Ont., and an analysis of a water from the boring at Maisonneuve, on the Island of Montreal. Of the foregoing the two first and the last mentioned, promise to prove of therapeutic value."

4. "Analyses of limestones and dolomites. A series of analyses has been commenced of such of these stones as occur in sufficiently extensive deposits—and with due regard to the accessibility of the latter—to be available for building material. On completion of the analyses of a series of the foregoing, the absorbing power (for moisture) and strength (resistance to a crushing force) of the same will also be determined. Dressed cubes of these stones are on exhibition in the Museum, showing their appearance under various "toolings" and when polished. Altogether, the information available in regard to them will be of such a nature as to very greatly facilitate the selection of a material for any special constructive work."

5. "Gold and silver assays. The greater number of the specimens examined were from British Columbia, and of these the results of assay were in a great many instances of a highly encouraging nature."

6. "Miscellaneous examinations embracing the testing of clays, in regard to their suitability for the manufacture of brick or pottery; the examination of pyrites with reference to its value as an ore of sulphur, and a variety of work of a like nature."

"There has been a steady increase, over former years, in the number of those seeking information in regard to minerals, as touching their identity or economic value. In most instances the desired information was communicated in the course of a personal interview; it not unfrequently happened, however, that a more than cursory examination was called for, or the estimation of a particular constituent deemed desirable, in which case the results were communicated by letter. The total number of specimens received—brought or sent—during the period in question, was seven hundred and sixty-five; and the number of letters written—for the most part in connection with same, and partaking of the nature of reports—two hundred and fifty-seven."

"Mr. F. D. Adams has (with the exception of a little over two months, when he was engaged in field work), as assistant chemist, applied himself with great diligence to the work in hand, the result of his labors being the analyses of the mineral waters aforementioned."

"Mr. R. A. A. Johnston, the junior assistant chemist, has proved himself a zealous and good worker. Apart from the gold and silver assays he has completed the analyses of numerous limestones and dolomites, besides doing a good deal of minor work."

"The work in the Mineralogical section of the Museum has progressed in a very satisfactory manner. The permanent labelling—which must by reason of additions be a more or less continuous work—has been almost completed to date. A manuscript catalogue of the scientifically arranged collection of minerals has been prepared, and will shortly be ready for printing, and considerable progress has been made in the preparation of a catalogue of the economic collection of minerals. The collection, which now numbers five thousand seven hundred and sixteen specimens, has, during the past year, been augmented by the addition of some two hundred specimens, including the following presentations:—"

Allan, W. A., Ottawa:—
Magnetite, from the township of Mulgrave, Ottawa county, Q.

Ami, H. M., of the Geological Survey, Ottawa:—
Calcite (nail-head spar) from the new quarries at Hull, Ottawa county, Q.

Colton, G. H., Pembroke, O.:—
Chlorite, from West Bay, Lake Nipissing, O.

Casey, T., East Templeton, Q.:—
Quartz and calcite, from East Templeton, Ottawa county, Q.

Craib, Wm., Nicola Milling and Mining Company, B. C.:—
Silver-ore, from the "Joshua" claim, Stump Lake, B. C.
do "Tubal" claim, do.
do "King William" claim, Stump Lake, B. C.

Egan, H. K., Ottawa.:—
Magnetite, from the township of Litchfield, Pontiac county, Q.

Gragg, Isaac G., Manager, Eastern Development Company, Lim.:—
Chalcopyrite, from the Coxheath copper mine, Cape Breton, N. S.

Henderson, G., Nicola Valley, B. C.:—
Silver ore, from the "Star" claim, Stump Lake, B. C.

Haycock, E. B., Ottawa.:—
Bog iron ore, from vicinity of Fort Natatchewan, Montreal River, district of Nipissing, O.

Kilpatrick, S. J., Kingston, O.:—
Limestone from Wolf Island quarry, Wolf Island, Frontenac county, O.

Keefer, T. A., Port Arthur, O.:—
Silver ore, "Native silver and argentite" from the Porcupine mine, Loc. 96 T, township of Gillies, district of Thunder Bay, O.
Calcite, sphalerite and quartz from the "Rabbit Mountain" mine, district of Thunder Bay, O.; and amethyst, with calcite carrying argentite. An association of calcite, quartz and fluorite, and sphalerite. Quartz with sphalerite and argentite. Galena, pyrite and sphalerite in calcite. Galena, sphalerite and native silver in calcite. Fluorite and quartz. Argentite, all from the "Beaver" mine, district of Thunder Bay, O.

Kidd, W. J., Kingston, O., per T. C. Weston:—
Concretions from beach at Kingston, O.

Murphy, W. H. Ottawa:—
Sphalerite from Calumet Island, Pontiac county, Q.

Morris, W. J., Perth, O.:—
Hematite from the township of Darling, Lanark county, O.

MacNaughton, A. G.:—
Stibnite from West Gore, Hants county, N. S.

McKay, J., per Dr. G. M. Dawson:—
Argentiferous galena, from the "Acadia" claim, McDame's Creek, South Fork, Cassiar, B. C.

Parks, A., Sebastopol, Renfrew county, O.:—
Asbestus from lot 11, range 11, of Sebastopol, O.

Poole, H. S., Stellarton, N. S.:—
Anglesite from the Big Dome mine, Arizona, U. S. A.

Primrose, H.:—
Albertite from River John, west branch, Pictou county, N. S.

Warwick, F. W., Buckingham, Ottawa county, Q.:—
Mountain cork from the "Emerald" mine, township of Buckingham, Ottawa county, Q.

"Mr. R. L. Broadbent has been engaged in the permanent labelling of the specimens, which, as already stated, is now almost completed up to date,—in readjusting the entire collection of scientifically arranged minerals, which had become necessary by reason of the addition of a great many species not previously represented, and in the maintaining of the general collection in an orderly condition. The interest he has manifested in the work, and the diligence with which he has applied himself to the same, has in no small degree facilitated the work, and conduced to the marked progress made in this section of the museum."

"In the early part of the year, Mr. C. W. Willimott was engaged in making up collections of minerals, subsequently in re-sorting and arranging the contents of some two hundred and forty drawers of material employed for this purpose and which in the aggregate amounted to about two tons in weight. A great many species were found to be entirely unrepresented and in order to make good, as far as possible, this deficiency, he spent a portion of the summer months in visiting several of the mineral localities of the provinces of Ontario and Quebec, as also the coast line between Two Islands and Cape d'Or, Minas Basin, Nova Scotia, These visits resulted in the obtaining a large amount of fresh material, amongst which were a great number of handsome specimens, more especially of zeolites, and which as representing species not already shown in the collection or as serving to replace inferior specimens of the same species contained in it, proved a most desirable acquisition. Since his return he has been occupied in unpacking, sort-

ing and arranging this material, and more recently in making up collections of minerals and rocks for educational institutions, &c. Collections of this descriptien have, in the course of the year, been forwarded to:—

	Specimens.
High School, Aylmer	115
University of St. Joseph, Memramcook	115
Christian Bros. training school, Clonmel, Ireland	115
St. John's College, Man	115
Canadian Institute, Toronto	115
J. C. Tremblay, Chicoutimi	115
Lands and Works Department, B. C	54
Royal Military College, Kingston (supplementary)	30
W. C. Van Horne, C.P.R., Montreal (supplementary)	28
Industrial School, Montreal	117
High School, Port Arthur, Ontario	117
St. François Xavier College, Antigonish, Nova Scotia	117
Bolton Institute, Bolton Centre, Q	109
Academy of Mount St. Vincent, Halifax, Nova Scotia	109
St. Hyacinthe College, St. Hyacinthe, Q. (supplementary)	15
Dr. F. A. Genth, Philadelphia, Pennsylvania, U. S. A. (in exchange)	98
	1,484

PALÆONTOLOGY AND ZOOLOGY.

In these divisions Mr. Whiteaves reports as follows: "The letter-press of the illustrated paper on the Triassic Fossils of British Columbia, referred to in the annual report of last year, has been printed and distributed, and the lithographic plates to accompany it will soon be ready. The second and concluding part of a paper entitled "Illustrations of the Fossil Fishes of the Devonian Rocks of Canada," has been written for the current volume of Transactions of the Royal Society of Canada, and is now in type. It consists of twenty pages quarto of descriptions, and is illustrated by two full page plates, and by four of double the ordinary size. The greater part of the manuscript of another illustrated report, "On some Cretaceous Fossils from British Columbia, the North-West Territory and Manitoba," has been written and it is hoped that the whole will be ready for the printer early in the spring. The part written before the 31st of December, 1888, includes descriptions of the various species obtained by Dr. Dawson at the Rink Rapids of the Lewis River in 1887, as well as of those collected by Mr. McConnell, from the Rocky Mountains, three miles north of the east end of Devil's Lake in 1886, and from the Liard River in 1887. A preliminary examination has been made

of a large collection of fossils from the Niagara formation at the north end of Lake Temiscamingue, made by Dr. R. Bell in 1887; of a series of fossils from the Devonian rocks of Lakes Manitoba and Winnipegosis, collected by Messrs. Tyrell and Dowling in 1888; of various fossils from the Cretaceous rocks of Lake Labarge, the Rocky Mountains and the Porcupine and Yukon Rivers, collected by Dr. Dawson and Mr. R. G. McConnell in 1887-88; and of some Cretaceous invertebrata from Millwood, Manitoba, obtained by Mr. J. B. Tyrrell in 1888. During the months of July and August, I was occupied in collecting fossils, with Mr. Tyrrell, from the Devonian rocks at the north end of Lake Manitoba, when, as will be seen in the list of additions to the Museum, a large number of specimens was secured. In the upper flat of the Museum, a new upright wall case has been erected, which is now filled with the larger fossils of the Trenton group, all of which are now properly labelled. Some fine fossil plants from the Carboniferous formation of the South Joggins coast, including a trunk of *Dadoxylon* some five feet in height, and more than a foot in diameter, have been added to the collection during the year. New upright glass cases have also been made for the reception of some remarkable mammalian remains from the Tertiary rocks of the Cypress Hills, North-West Territories, and for a series of large dicotyledonous leaves from the Laramie deposits near Calgary, both collected by Mr. Weston during the past summer.

"In the small room devoted to the exhibition of mounted specimens of Canadian mammalia and birds, the wooden shelves in the wall cases have been entirely replaced by strips of glass. A large number of duplicate or inferior specimens of Canadian birds has been removed and their places filled, either with other species or with much better specimens, and nearly the whole series has been labelled in accordance with the check-list of North American Birds published by the American Ornithologists Union. The following is an estimate of the number of specimens and species of native vertebrata exhibited in the Museum in December, 1888.

Mammalia.

99	mounted specimens of	59	species.
8	mounted heads of	8	do
4	mounted skeletons of	4	do
27	separate skulls of	17	do

Birds.

448 mounted specimens of 300 species.

Turtles.

3 mounted specimens of 2 species.

"Among the more attractive of the zoological specimens received during the year may be mentioned a skeleton of the White Porpoise or Beluga (*Delphinapterus catodon*), prepared from a specimen caught in the Lower St. Lawrence, and secured for the Museum by Dr. B. J. Harrington, of McGill University, Montreal; an albino variety of the Grey Squirrel, shot at Lundy's Lane, Ont.; and a remarkable colour variety of the Bronzed Grackle, from the vicinity of Brandon, Manitoba. A commencement has been made of a collection of the eggs of Canadian birds, and those of some rather rare or local species have been recived from Manitoba, the North-West Territory, British Columbia and Hudson's Bay and Strait. The series of recent mollusca from British Columbia, already in the Museum, has been much improved by the addition of several rare species from that province, kindly presented by the Rev. G. W. Taylor, formerly of Victoria, Vancouver Island, and some additions have been made to the collection of foreign shells. The number of official letters written during the year is 184, and throughout the months of September and October, the duties of Acting Director have been performed by the writer."

Mr. T. C. Weston reports that from the first of January to the latter part of June his time was occupied in Museum work in the palæontological and ethnological branches, and in making sections of rocks and fossils for microscopic examination. From the 28th of June to the 17th of September he was engaged in field work, in collecting fossils at various localities in the North-West Territory and at the South Joggins coast in Nova Scotia. The remainder of his time has been occupied in labelling and preparing fossils, &c., for exhibition in the Museum.

Mr. H. M. Ami has examined collections of fossils from upwards of one hundred localities in central Ontario, between Lake Simcoe and Belleville; from thirteen localities in the province of Quebec; from sixteen in New Brunswick, and from several at or in the neighborhood of Arisaig, N. S. With the view of ascertaining the exact geological horizons of the rocks from which they were collected, the species represented at each of those localities have been determined, as far as possible, and systematic lists of them have been made and placed upon record. He has written the manuscript of labels, which have since been printed, for the Cretaceous and Laramie fossils of northern Alberta described by the writer in 1887; for the Tertiary fossils of Skonun Point in the Queen Charlotte Islands; for the Laramie plants of the North-West Territory described by Sir William Dawson in 1887, and for the Cambrian fossils in the Museum, of which latter series he has re-classified and revised the nomenclature. From the duplicates in the Museum he has selected and labelled three sets of fossils, one of

which has been sent to St. Laurent College, Montreal; one to St. François College, Antigonish, N. S.; and one to the Manitoba College at Winnipeg. Some specimens of fossil sponges from the Museum have been loaned to Dr. J. G. Hinde for examination and study. From the 17th of September to the 18th of October, Mr. Ami was engaged in field work in the province of Quebec, under Dr. Ells, and succeeded in obtaining a considerable number of fossils. He has also collected a somewhat large series of fossils from the Chazy, Trenton and Utica formations around Ottawa.

The following collections have been received during the year from members of the staff:—

Dr. Selwyn:—

Three specimens of *Prasopora lycoperdon*, Vanuxem (*P. Selwyni*, Nicholson) from the Trenton Limestone of Snake Island, Georgian Bay, Ont.

Dr. G. M. Dawson:—

Skin (since mounted) of the Hoary Marmot (*Arctomys caligatus*) from the mountains at the head of the Tulameen River, and about 300 specimens of plant and insect remains from the Tertiary rocks of British Columbia.

Dr. R. Bell:—

Specimen of a fresh-water shell from the Sturgeon River and one from the Vermilion River, Ont.

Professor Macoun:—

Eighty-nine specimens of birds from the neighbourhood of Ottawa.

Dr. R. W. Ells, N. J. Giroux and H. M. Ami:—

1500 fossils from various localities on both sides of the St. Lawrence from Bécancour River to Rivière du Loup (en bas) P. Q.

R. G. McConnell:—

500 fossils from the Devonian rocks of the Mackenzie and Hay Rivers; also seventy-five fossils from the Cretaceous rocks of the Mackenzie and Porcupine Rivers, and from the Yukon and Northern Rocky Mountain regions. About one hundred specimens of fossil plants from the Bear River Miocene, Mackenzie River.

Skins of an adult male of the Long-tailed Jaeger (*Stercorarius longicaudus*) of the Long-tailed Duck (*Clangula hyemalis*), of

the Surf, and Whitewinged Scoter (*Oidemia perspicillata* and *O. Deglandi*), all from the mouth of the Bear River, Mackenzie River.

J. B. Tyrrell:—

Fossils from the Cretaceous rocks at Millwood, Man., from the Hudson River formation at Stony Mountain, Man., and at Streetsville, Ont.

Skin of Franklin's Gull (*Larus Franklini*), a young loon (*Urinator imber*), and eggs of the Black Tern (*Hydrochelidon nigra Surinamensis*).

Twenty-five specimens of recent fresh water shells from the Assiniboine River, Man.

J. B. Tyrrell and J. F. Whiteaves:—

About 500 fossils from the Palæozoic rocks at the northern end of Lake Manitoba, and a small series of the recent Unionidæ of the same lake and the Fairford River.

T. C. Weston:—

Portion of a large skull, jaws, detached teeth, vertebræ and limb bones of various mammalia (nearly 300 specimens in all) from the older Miocene of the Cypress Hills.

300 fossil shells, &c., from the Belly River Series of Milk River Ridge, N.W.T.

Sixty specimens of dicotyledonous leaves, &c., from the Laramie formation at Calgary and the Red Deer River, N.W.T.

Thirty specimens of fossil plants from the Carboniferous rocks at the South Joggins, N. S.

H. M. Ami:—

300 fossils from the Utica, Trenton and Chazy formations about Ottawa, 100 nodules from Green's Creek, and fifty fossils from Glenora, Ont.

W. McInnes:—

Forty-five fossils from the Silurian rocks of the region between Rimouski and Lake Temiscouata, P. Q., and egg of the loon (*Urinator imber*).

J. Marshall:—

One Snapping Turtle, caught near Ottawa.

D. B. Dowling:—

150 fossils from the Devonian limestone of Lake Winnipegosis.

J. M. Macoun :—

Seventeen skins of birds and seven skins of mice from the Athabasca River.

The additions to the palæontological, zoological and ethnological departments of the Museum, by presentation, exchange or purchase, are as under :—

By Presentation :

F. R. Latchford, Ottawa:—

Four specimens of *Limnæa ampla*, Mighels, from Brome Lake, P.Q.

Major A. Hamlyn Todd, Ottawa :—

Fine specimen of the Black or Silver Grey Fox (*Vulpes vulgaris*, var. *argentatus*) from the head of Lake Winnipeg. A vixen three years old, in winter fur and in the flesh.

W. H. Harrington, Ottawa :—

A White-footed Mouse (*Hesperomys leucopus*) caught in Gilmour Street, Ottawa; in the flesh.

Ruggles Wright, Hull, P. Q. :—

A nearly complete skeleton of a very young seal, probably *Phoca Groenlandica*, from the Post Pliocene clay at Hull.

Captain C. Berkeley Powell, Ottawa :—

Stuffed specimen of a beaver (*Castor fiber*) which was killed at White Partridge Creek on the Petewawa River in the winter of 1885-86.

T. G. Lear, Ottawa :—

Osprey (*Pandion haliætus carolinensis*) shot on the Rideau River, in the flesh.

E. Browne, Ottawa :—

Specimen of the Hairy-tailed Mole (*Scapanus Breweri*) caught swimming in the Ottawa River between Britannia and Skead's mills; in the flesh.

E. H. Carter, Ottawa :—

Flying Squirrel (*Sciuropterus volucella*), shot at Aylmer, P.Q.: in the flesh.

J. A. Doyon, Ottawa :—

A sharp-shinned Hawk (*Accipiter velox*) shot near Ottawa; in the flesh.

Miles Spencer, Fort George, Hudson's Bay:—

Two eggs of the Willow Ptarmigan (*Lagopus lagopus*), one egg of the American Bittern (*Botaurus lentiginosus*), one of the Yellow-legs (*Totanus flavipes*), and three undetermined eggs, all from Fort George.

G. S. Cotter, Moose Factory, Hudson's Bay:—

A collection of butterflies and beetles from Moose Factory.

W. G. Kidd, Kingston, Ont.:—

A large trilobite (*Asaphus platycephalus*) from the Trenton limestone at the village of Wellington, Prince Edward county, Ont.

A. F. Grant, Ottawa:—

Skin of a Long-billed Curlew (*Numenius longirostris*) shot near Fort Macleod, Alberta.

Thomas Patterson, Ottawa:—

Slab of crinoidal limestone from Banff, N. W. T.

John Rutledge, Sydenham, Ont.:—

Antler of American Elk or Wapiti (*Cervus Canadensis*) ploughed up in what was once a cedar swamp, three miles from Sydenham.

Professor J. Fowler, M.A., Queen's University, Kingston, Ont.:—

An unusually perfect and well preserved specimen of *Lituites Americanus*, Emmons, from the Black River limestone of Wolfe's Island, near Kingston.

Dr. A. Jukes, Regina, N.W.T.:—

One atlas, one vertebra, three portions of jaws, four teeth and fragments of teeth and of limb-bones of various fossil mammalia from the "White River" beds of the Cypress Hills, N.W.T., also one specimen of a small *Inoceramus*.

Andrew Christie, Pincher Creek, Alberta:—

Skin of a Bushy-tailed Wood Rat (*Neotoma cinerea*) from Pincher Creek.

Albert J. Hill, New Westminster, B.C.:—

Fifteen specimens of six species of fossil shells and one calcareous annelid tube from the Post Pliocene clays on the bank of the Fraser River at New Wesminster.

Rev. G. W. Taylor, Billings' Bridge, Ont. :—

Specimens of fourteen rare species of marine shells from the coast of British Columbia, one small crab from the same coast, and numerous examples of *Anodonta Nuttalliana* Lea, from Vancouver Island.

G. E. McMartin, St. Andrews, P.Q. :—

A Saw-whet or Acadian Owl (*Nyctale Acadica*) from the Little Rouge, a tributary of the North Nation River, P.Q.; in the flesh.

Dr. T. Tunstall, Kamloops, B.C. :—

One jade scraper and two stone hammers, from Lytton, B.C.

John Murray, Spence's Bridge, Thompson River, B.C. :—

Four flint arrow heads and one small stone paint pot, from the neighborhood of Spence's Bridge.

J. W. McKay, Kamloops, B.C. :—

Three flint arrow heads and four chipped flints, from Kamloops.

D. Armit, Manitoba House, Kinosota, Man. :—

Guard of a Belemnite, from Cretaceous rocks on the east bank of the Assiniboine, a little below the mouth of the Little Souris River; do., from rocks of similar age at Ochre River, Riding Mountain, Man., and a flint arrow head from Fort Ellice, N.W.T.

Dr. J. G. Hinde, Croydon, England :—

Specimens of *Syringolites Huronensis*, Hinde, from the Niagara Limestone of the Manitoulin Islands.

John Macoun, Ottawa :—

Pair of the Chickadee (*Parus atricapillus*); do. of the Red-breasted Nuthatch (*Sitta Canadensis*), a female Goldfinch (*Spinus tristis*) and two male Pine Grosbeaks (*Pinicola enucleator*), all from the neighborhood of Ottawa; skins, which have since been mounted.

E. G. White, Ottawa :—

Specimens of the Silvery-haired Bat (*Scotophilus noctivagans*) from Ottawa, in the flesh, and an American Crow (*Corvus Americanus*), also in the flesh.

Brother Secordian, Hull, P.Q. :—

Specimen of the Brown Bat (*Scotophilus fuscus*) from Hull; in the flesh.

W. E. Saunders, London, Ont. :—

Two small trilobites (*Phacops rana*) from drifted Devonian limestone at London.

John P. Esmonde, Ottawa :—

Necklace procured from a Blood Indian at the Blood Indian Reserve, twenty-two miles south of Fort Macleod.

B. K. Lowry, Maple Creek, Assa. :—

One vertebra of a buffalo with an iron arrow head imbedded in it, and another with a leaden bullet partly buried in it, both from the Cypress Hills.

By Exchange :—

From Dr. W. H. Rush, U.S.N., Philadelphia :—

Specimens of seventeen rare specimens of marine sholls from Key West, the Bahamas, Yucatan Channel, Florida Straits, &c.

By Purchase :—

Large Beaver (*Castor fiber*) from Big Lake, Pontiac county, Ont., in the flesh.

Fine specimen of an Ammonite (*Placenticeras placenta*) from the Cretaceous rocks of the St. Mary River.

Skin (since mounted) of an Albino Grey Squirrel (*Sciurus Carolinensis*) shot at Lundy's Lane, Ont.

Remarkable color variety of the Bronzed Grackle (*Quiscalus quiscalus æneus*) from the neighborhood of Brandon, Man.

Pair of Loucheux (*Kutchin*) Indian snowshoes, from Lapierre's house, Porcupine River, Yukon District, and a typical Loucheux knife.

Skeleton of the Star-nosed Mole (*Condylura cristata*) mounted by M. Jules Bailly, Montreal.

Molar of Mammoth (*Euelephas*), dug up in 1887 at St. Catharines, Ont.

One large Snapping Turtle (*Chelydra serpentina*) and a few fine stone implements of Indian manufacture, all from the county of Grey, Ont.

BOTANY, ETC.

The work in this section, under Professor Macoun, has made good progress during the year. Part IV, 248 pages R. 8vo. of the Catalogue of Canadian Plants, referred to in the summary report for 1887, as then passing through the press, was published early in the year and has since been distributed to scientific institutions and botanists in Europe and in America, and has been widely criticized in every case in the most complimentary terms.

During the first week in April, Professor Macoun made a list of all the mounted birds exhibited in the Museum, and found that there were 282 species, represented by 429 specimens. In the drawers 170 species were represented by 352 skins, 52 of which were of species not on exhibition in the cases. A list was then made out of all the birds known to Canada, which shows 564 species. This work was preliminary to that of the preparation of a complete catalogue of Canadian birds of the same character as the catalogue of plants, and Professor Macoun is now engaged on it.

Collections of plants to be examined and named were received during the year from Newfoundland, and from every province in the Dominion, except Prince Edward Island, in all over 1,500 specimens; these were all named and returned. Between January and the 15th of April there were mounted and placed in the herbarium by Mr. J. M. Macoun, 3,015 sheets of specimens, as under:—

Phænogams:—	
Canadian	850
European	775
United States	615
Cryptogams	775

During the same period there were sent to various museums, colleges and individuals 2,153 sheets of specimens, including 400 to McGill College, 300 to Columbia College, New York, 200 to the Department of Public Instruction, Quebec, and 200 to the British Museum. A large number of specimens received in exchange for those sent out, were mounted and placed in the herbarium which now contains 17,516 sheets.

Mr. J. M. Macoun left for the field on the 30th April with a Dominion land survey party. He collected plants and bird skins in the valleys of the Athabasca and Churchill rivers, returning to Ottawa on the 25th of November.

On the 18th of June, Professor Macoun left for Prince Edward Island. Twelve weeks were spent there studying its natural history and collecting specimens. Over 1,100 species of plants were secured, and valuable and interesting notes were made on the summer birds of the island. Returning on the 10th of September to Ottawa, Professor

Macoun then proceeded to Northumberland county, Ontario, where three weeks were spent collecting mosses and other material for Part V of the Catalogue of Canadian plants, the writing of which was then being commenced.

M. Pearson, of Manchester, England, has kindly given a report on the Hepaticæ—165 species—and Dr. Kindberg has examined and named nearly all the mosses, so that Professor Macoun is now in a position to complete Part V of the catalogue during the present winter.

Besides the collections of plants already mentioned, Dr. G. M. Dawson made an extensive one in the region around Kamloops, in British Columbia. Specimens of nearly 1,000 species, chiefly arctic plants, have been received from the British Museum in exchange. These are nearly all of the type species described by Sir W. Hooker in the *Flora Boreali-Americana* published in 1840. Most of the specimens were collected by Menzies, Douglas and Barclay on the Pacific Coast, by Drummond in the Rocky Mountains, and by Franklin and Richardson on the Arctic Coast.

MAPS.

There is now in course of preparation, and in various stages of readiness for publication, a large number of maps covering areas in all parts of the Dominion, amounting in the aggregate to 41,460 square miles. Some of these will require to be reduced for publication. They are as follows:—

No.	——	Scale.	Area in Sq. Mls.
1	Yukon district, N. W. T., and adjacent northern part of British Columbia..................	8 miles to 1 inch.	
2	Index map of above.		
3	Big River, Great Whale River, &c., east coast of Hudson's Bay..........................	8 do 1 do	
4	British Columbia, part of southern interior.....	4 do 1 do	
5	North-western Manitoba, preliminary map.....	8 do 1 do	12,000
6	Western Ontario, Rainy River district.........	4 do 1 do	3,456
7	do Hunter's Island..............	4 do 1 do	1,450
8	Ontario, Madoc and Marmora township........	½ do 1 do	105
9	do Lake Temiscaming to Lake Huron.....	4 do 1 do	180
10	do Preliminary map, Lakes Temagami and Temiscaming	2 do 1 do	3,828
11	do General map..........................	4 do 1 do	
12	do sheet 115 of same.....................	4 do 1 do	3,456
13	Quebec, N.-E. ¼ sheet (Eastern Townships map)	4 do 1 do	4,500
14	do phosphate deposits, Ottawa county.....	½ do 1 do	210
15,16	do and New Brunswick, ¼ sheet, 17 N.-E. and 18 S.-E........................	4 do 1 do	4,593
17,18	Nova Scotia, ¼ sheet, 4 N.-E. and 4 S.-E.........	4 do 1 do	6,912
19,20	do parts of ¼ sheets 11 N.-W. and S.-W.	4 do 1 do	770
21	Various traverses in region of Mackenzie and Porcupine Rivers being reduced.		41,460
	Nos. 1, 2, 3 and 21, are plans of routes of exploration by land, river and lake, of a total length of about 5,900 miles.		

LIBRARY.

Dr. Thorburn reports that from 2nd January to 31st December, 1888, the total number of publications issued in connection with the Survey, including Annual Reports, parts of ditto, special reports and maps, has been 9,992. Of these, 6,567 were distributed in Canada, the remainder were sent to foreign countries, including Great Britain and Ireland, the Continent of Europe, the United States, South America, India, China, Japan, Australia, &c.

The number of reports in French distributed was 502.

There were received during the past year, as exchanges, 2,000 publications, including reports, transactions, proceedings, memoirs, periodicals, pamphlets and maps. Besides these, 56 publications were purchased and 40 scientific periodicals subscribed for.

There were 150 volumes bound during the year. The number of letters received relating to library matters was 1,927. The letters sent out by the Librarian were 1,119. There are now in the library about 7,500 volumes and 2,600 pamphlets.

VISITORS.

The number of visitors to the Museum during the year, from 1st of January to the 31st December, was 17,414. being a decrease of 161 as compared with the previous year.

In my summary report for 1875, I called attention to the question of opening the Museum on Sunday afternoon, and I then gave some very remarkable statistics of attendance, the result of this course having been adopted at the Australian Museum in Sydney, showing that on the 52 Sundays, afternoons only, the daily attendance was largely in excess of that of the 313 week days, the average being 986 on Sundays and 275 on week days; such a fact needs no comment, and I venture again to express a hope, in the interests of education and knowledge, that the time is not remote when a similar experiment will be tried in Ottawa.

There will, doubtless, be strong objections urged against such action, based chiefly, if not entirely, on the very erroneous, but unfortunately very prevalent idea, that a museum is a place of amusement, whereas it is essentially as much a place of instruction as is the church and Sunday-school; and the principal difference between the two, concisely stated, is, that in the Museum the *work*, and in the church and school the *word*, of the *Creator* is expounded. This admitted, there seems no obvious or intelligible reason why the one establishment should be closed and the other opened on the Sabbath.

STAFF, APPROPRIATION, EXPENDITURE AND CORRESPONDENCE.

The strength of the staff at present employed is 53, viz., professional 35, ordinary 17.

During the calendar year Messrs. Robert Chalmers and William McInnes were appointed as geologists to the permanent staff, and the following promotions were made:—

Professor John Macoun, from the 1st Class to Assistant Director.

Mr. Chas. W. Willimott, from the 3rd Class to 2nd Class.

The amount available for the fiscal year ended 30th June, 1888, was:—

	$ cts.	$ cts.
Civil List appropriation	....	44,800 00
General Purpose Appropriation	....	57,598 43
The expenditure may be summarized under the divisions named as follows:—		
Civil List Salaries	42,478 82	
Wages of temporary employés	16,671 55	
Exploration and survey	23,255 27	
Printing and lithography	11,655 28	
Purchase of specimens	2,091 85	
Purchase and binding of books, and purchase of instruments	967 48	
Laboratory apparatus and chemicals	324 87	
Stationery, mapping materials and Queen's Printer	1,294 12	
Incidental and other expenses	1,733 12	
	100,472 36	
LESS—Paid in 1887	3,930 44	
	96,541 92	
ADD—Advances to field explorers	3,479 42	
	100,021 34	
Unexpended balance Civil List Appropriation	2,321 18	
do of Contingency do	55 91	
	102,398 43	102,398 43

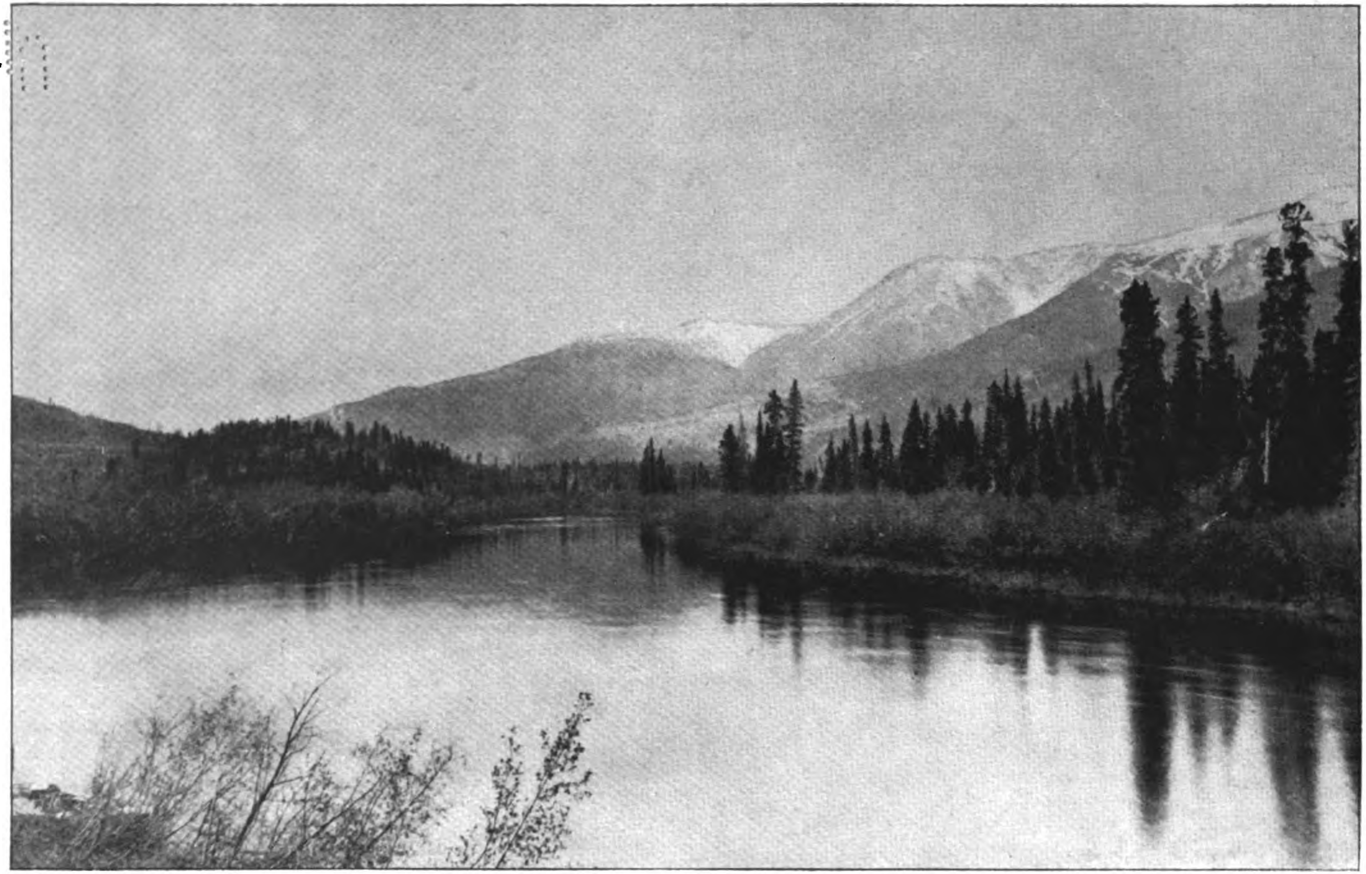
The correspondence of the branch shows a total of 7,662 letters sent, and 6,564 received, from 1st January to 31st December, 1888.

In conclusion I may again call attention to the inadequate Museum accommodation, referred to in previous reports, in the hope that some steps will be speedily taken to obviate this difficulty, which is constantly increased by the large annual additions now being made to the collections.

To raise the roof of the building and make a wide gallery around the upper flat supported with iron pillars, would be the least costly plan, and while much improving the external appearance of the building, would afford all the accommodation needed for some time to come.

ALFRED R. C. SELWYN,

Director.



G. M. DAWSON, PHOTO., JUNE 19, 1887. G. E. DESBARATS & SON, ENGRAVERS & PRINTERS, MONTREAL

DEASE RIVER ABOVE "FIRST LAKE," LOOKING WEST

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA.

ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR.

REPORT

ON AN EXPLORATION IN THE

YUKON DISTRICT, N.W.T.,

AND

ADJACENT NORTHERN PORTION OF

BRITISH COLUMBIA.

1887.

BY

GEORGE M. DAWSON, D.S., F.G.S.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

MONTREAL:
DAWSON BROTHERS.
1888.

To ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S,

Director of the Geological and Natural History Survey of Canada.

SIR—I beg to present herewith a report on a portion of the Yukon District, N.W.T., and adjacent northern part of the Province of British Columbia. The exploration upon which this report is based was carried out as part of the work of the Yukon Expedition, of which I had the honour to be placed in charge. The further explorations and surveys carried out by Messrs. R. G. McConnell and W. Ogilvie will form the subject of separate reports.

It may be explained that the greater part of the present report was completed in June last, but that having been engaged in field work during the summer, it was impossible to send the manuscript to the printer at that time.

I have the honour to be, sir,

Your obedient servant,

GEORGE M. DAWSON.

OTTAWA, Dec. 1, 1888.

NOTE.—The bearings throughout this report are given with reference to the true meridian, unless otherwise specially noted.

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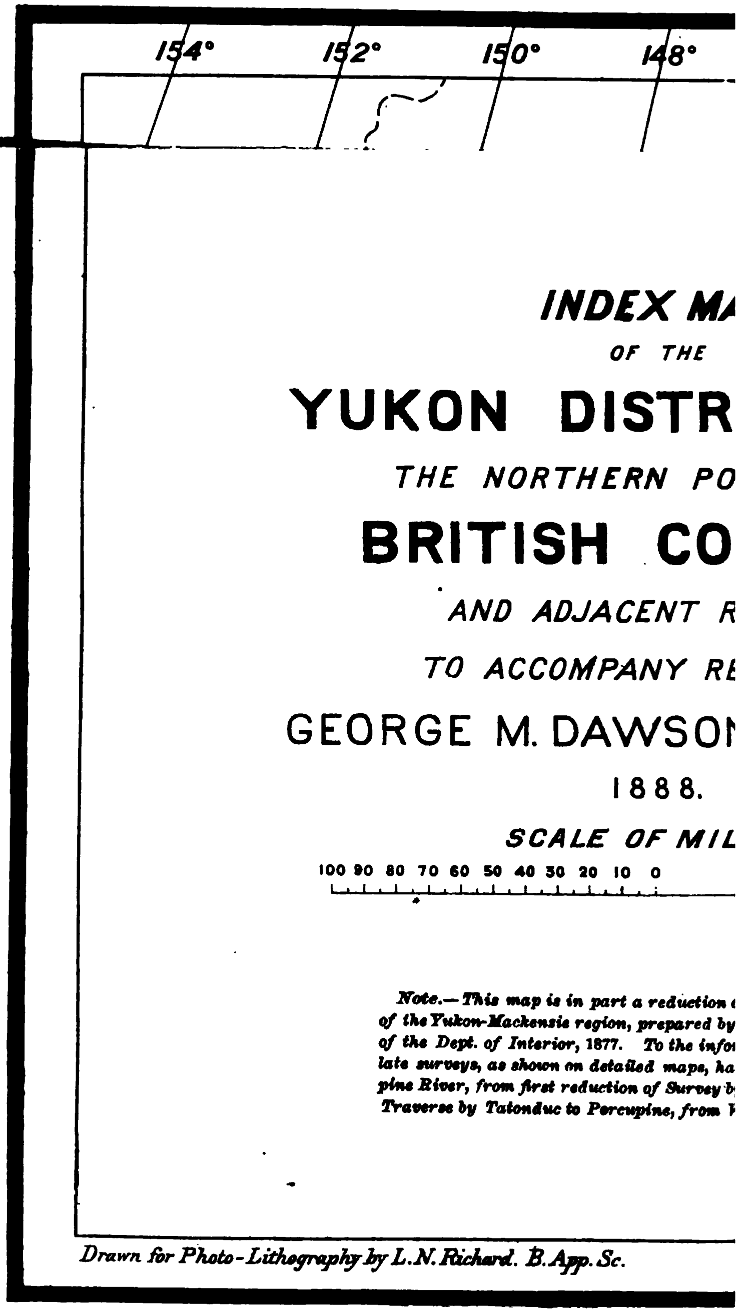
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AND ADJACENT
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GEORGE M. DAWSO
1888.
SCALE OF MIL
100 90 80 70 60 50 40 30 20 10 0
Note.—This map is in part a reduction
of the Yukon-Mackenzie region, prepared by
of the Dept. of Interior, 1877. To the info
late surveys, as shown on detailed maps, ha
pine River, from first reduction of Survey
Traverse by Tatonduc to Percupine, from
Drawn for Photo-Lithography by L.N. Richard. B.App. Sc.

REPORT

ON AN EXPLORATION IN THE

YUKON DISTRICT, N.W.T.,

AND

ADJACENT NORTHERN PORTION OF

BRITISH COLUMBIA.

BY

GEORGE M. DAWSON, D.S., F.G.S.,

Introductory.

Yukon Expedition.

The Yukon expedition, to which the present report relates, was undertaken for the purpose of gaining information on the vast and hitherto almost unknown tract of country which forms the extreme north-westerly portion of the North-west Territory. This tract is bounded to the south by the northern line of the Province of British Columbia (Lat. 60°), to the west by the eastern line of the United-States territory of Alaska, to the east by the Rocky Mountain Ranges and 136th meridian, and to the north by the Arctic Ocean. The region thus generally defined is referred to as the Yukon district, this name being rendered appropriate from the fact that the greater part of its area lies within the drainage-basin of the river of that name.

Yukon district.

Area of Yukon district.

The Yukon district, as above defined, has a total area of approximately 192,000 square miles, of which, according to the most recent information, 150,768 square miles is included in the watershed of the Yukon. The superficial extent of the district may perhaps best be realized when it is stated that it is nearly equal to that of France, greater than the United Kingdom by 71,100 square miles, ten times the area of the province of Nova Scotia, or nearly three times that of the New England States. It is unnecessary to add that the present report must be considered merely as a first contribution to our knowledge of this wide country.

Purpose of the Expedition.

The immediate necessity for the exploratory and surveying work undertaken by the expedition, arose from the fact that somewhat important developments of placer gold-mining had of late been attracting a yearly increasing number of miners and prospectors into a portion of the district in question; and the work decided on, included the preliminary determination of the point at which the Yukon or Pelly River crosses the 141st meridian, which here constitutes the boundary between the North-west Territory and Alaska.

Organisation.

The writer was placed in general charge of the expedition, with Mr. R. G. McConnell, B.A., and Mr. J. McEvoy, B.Ap.Sc., also of the Geological Survey, as assistants, while Mr. W. Ogilvie, D.L.S., was intrusted with the conduct of instrumental measurement and the astronomical work in connection with the determination of the position of the 141st meridian.

Work by Mr. Ogilvie.

In consequence of information gained from persons having some knowledge of the region to be traversed, it was decided that Mr. Ogilvie should carry out an instrumentally measured traverse of the route from the head of Lynn Canal to the Lewes and along the line of the river to the 141st meridian, where he was to make arrangements for wintering, and in the spring and summer of 1888 continue his surveys north-eastward to the Mackenzie River and up that river to connect with previously surveyed lines on Athabasca Lake.

Work by the writer.

Having ascertained that there was a fair probability of his being able to carry a line of survey and exploration from the Cassiar district in northern British Columbia, by way of the Upper Liard and across the height of land to the Yukon basin, the writer decided on attempting that route, which, though known to be difficult, appeared to offer, in conjunction with Mr. Ogilvie's work, the best opportunity of adding to our knowledge of the country as a whole.

Work by Mr. McConnell.

Mr. McConnell was entrusted, in the first instance, with the instrumental measurement of the Stikine River, from the point to which surveys had previously been carried, as far as the head of navigation, and subsequently, with the exploration of the lower portion of the Liard River; the original intention being that he should return after reaching the Mackenzie, in the autumn of 1887, by the ordinary trade route up that river. Before we finally separated from Mr. McConnell,

Change of plan.

at the confluence of the Dease and Liard, however, so many unexpected delays had occurred, that it was considered advisable to instruct Mr. McConnell to endeavour to make arrangements for passing the winter of 1887-88 on the Mackenzie, and subsequently to descend the Mackenzie, cross the northern extremity of the Rocky Mountains to the Porcupine River, and by following that river and ascending the Lewes, to return to the Pacific Coast at Lynn Canal. This arrangement further

provided for the examination of a great additional region of which the geological structure was altogether unknown. Mr. McConnell has since successfully completed the arduous journey thus outlined. A preliminary report of his work, as far as the mouth of the Liard, is given in conjunction with that of the writer, in Part III, Annual Report of the Department of the Interior, 1887. A progress report of Mr. Ogilvie's work forms a portion of Part II of the same volume. Reports.

The present report relates exclusively to the exploration by the writer in 1887, with the following exceptions:—(1.) Mr. McConnell's traverse and geological observations on a portion of the Stikine are included in the description of that river and are incorporated on the accompanying map. (2.) The Lewes River, as laid down on the map, (with the exception of the mountain features in its vicinity and some additions to the outlines of the lakes), is from the survey of Mr. W. Ogilvie. The results of Mr. McConnell's work, carried out after his separation from us at the mouth of the Dease, will form the subject of a separate report of the Geological Survey, and Mr. Ogilvie will also prepare an independent report of his survey on his return. The present report.

In order to present within a reasonable compass the results of the portion of the work of the expedition here reported on, the daily record of progress, which the unknown character of the country traversed might otherwise appear to warrant, has been discarded, and but slight allusion is made to the modes of travel adopted and the numerous vicissitudes encountered during our journey. This, while resulting in the loss of interest which a connected narrative might possess, has distinct advantages in other respects. On account of the extent of the region treated of, the descriptive portion of the report has been divided into separate chapters, each treating of a distinct portion of our route and constituting practically a separate short report. In the pages immediately following this introduction, some general notes on the region as a whole, are given. Arrangement of matter.

Summary of Proceedings.

The following summary of our proceedings in connection with the expedition is substantially the same as that given in my preliminary report before alluded to.— Journey to the Stikine.

We left Ottawa on the 22nd of April, 1887, travelling by the Canadian Pacific Railway to Victoria, but, in consequence of irregularity in the sailing dates of the Alaskan mail steamers, were unable to reach Wrangell, at the mouth of the Stikine River, where our work may have said to have begun, till the 18th of May. Here Mr. McConnell stayed behind, for the purpose of getting Indians and canoes to enable him to make a micrometer survey of the Stikine from the end of the

line measured by Mr. J. Hunter in 1877, to Telegraph Creek, while I proceeded up the river by the first steamer of the season to Telegraph Creek, the head of navigation. From this place, goods are carried by pack animals to Dease Lake, the centre of the Cassiar mining district; and here again a delay of several days occurred, as the animals had not been brought in from their range or shod for the season's work at the date of our arrival. Finally, on June 5th, we reached the head of Dease Lake, and found the greater part of the lake still covered with ice. It was not till the 9th that we were able to reach the point on the shore near Laketon at which two men, previously sent on in advance with an Indian packer, were sawing lumber for boats. Seven days were here busily employed in this work and in constructing three boats for the purposes of the expedition. On the evening of the 16th, a strong wind having broken up the remaining barrier of ice, we reached Laketon with our boats, Mr. McConnell, with a crew of five Coast Indians intended for my work on the Upper Liard, having meanwhile joined us. On the 18th, having completed our supplies and outfit at Laketon, we left that place, and on the 23rd reached the "Lower Post" at the confluence of the Dease and Liard Rivers. Here Mr. McConnell, with one boat and two men, separated from us for the purpose of surveying and geologically examining the Lower Liard.

Journey to Dease Lake.

Building boats.

Departure from Dease Lake.

Personnel of parties.

On leaving the confluence of the Dease and Liard, my own party included, besides myself, Mr. McEvoy, Messrs. L. Lewis and D. Johnson, engaged at Victoria, two Tshimsian and three Stikine (Thlinkit) Indians, all good boatmen. Two local Indians hired as guides, and to help in portaging, deserted a day or two after engaging, and from the "Lower Post" to near the confluence of the Pelly and Lewes, for an interval of more than six weeks, we met neither whites nor Indians.

Journey to Frances Lake.

The ascent of the Liard and Frances rivers to Frances Lake proved unexpectedly difficult and tedious, the rivers being swift throughout and three bad cañons having to be passed through. Frances Lake was reached on the 8th of July, and after spending a few days in examining and mapping the lake, making the observations necessary to fix its position, and in the endeavour to find some Indian trail by which we might travel across to the Pelly, we began the work of portaging on the 17th.

Journey overland to Pelly River.

As we had been unable to discover any route now in use by the Indians, and no trace whatever remained of the trail employed by the Hudson Bay Company in former years; and further, as no local Indians could be found to act as guides or to assist in carrying our stuff, it was evident that the crossing of this portage (which had been estimated by Mr. Campbell at about 70 miles in length) would be a difficult matter,

and that we might indeed find it impossible to carry over a sufficient supply of provisions for work on the Pelly. We therefore, constructed a strong log *câche* on the shore of Frances Lake, and left there, to be taken to Dease Lake by the Indians when they returned, everything we could possibly dispense with. Had we been unable to effect the portage, there was in our *câche* a sufficient supply of provisions to enable the whole party to return to the "Lower Post." After a very toilsome journey, we were, however, so fortunate as to reach the bank of the Upper Pelly on the 29th of July, with still nearly a month's provisions for four persons, our instruments and a small camping outfit, a canvas cover from which a canoe might be constructed, and the tools and nails for building a wooden boat, should that prove to be necessary. Our Indians, who had for a long time been very uneasy because of their distance from the coast and the unknown character of the country into which they had been taken, were here paid off, and to their great delight allowed to turn back.

As a dangerous rapid was reported to exist on the upper part of the Pelly, it was decided to construct a canvas canoe in preference to building a boat, which it might prove impossible to portage past the rapid. Having completed the canoe, we descended the Pelly, making a portage of half a mile past Hoole Rapid or Cañon, and arrived at the confluence of the Lewes branch with the Upper Pelly on the 11th of August. We had now reached the line of route which is used by the miners, and expected to find, at the mouth of the Lewes, a prearranged memorandum from Mr. Ogilvie, from whom we had separated in May. As we could not find any such notice, and as Mr. Ogilvie had not been seen on the lower river by a party of miners whom we met here on their way up the Lewes, we were forced to conclude that he had not yet reached this point. The same party informed us that there had been few miners during the summer on the Stewart River, where most of the work had been carried on in 1886, but that in consequence of the discovery of "coarse" gold on Forty-mile Creek, over 200 miles further down the river, most of the men had gone there. We were also told that Harper's trading post, where I had hoped to be able to get an additional supply of provisions should we fail to connect with Mr. Ogilvie, had been moved from the mouth of the Stewart to Forty-mile Creek. From the place where we now were we still had a journey of nearly 400 miles to the coast, with the swift waters of the Lewes to contend against for the greater part of the distance. If therefore it should have become necessary to go down stream 200 miles to Forty-mile Creek for provisions, so much would have been added to our up-stream journey that it would become doubtful whether we should be able to afford time for geological work on

Descent of the Upper Pelly.

Proceedings at Mouth of Lewes.

the Lewes, and yet reach the coast before the smaller lakes near the mountains were frozen over. I therefore decided to set about the building of another boat, suitable for the ascent of the Lewes, and on the second day after we had begun work, Mr. Ogilvie very opportunely appeared. After having completed our boat and obtained Mr. Ogilvie's preliminary report and map-sheets, together with the necessary provisions, we began the ascent of the Lewes, from the head-waters of which we crossed the mountains by the Chilkoot Pass and reached the coast at the head of Lynn Canal on the 20th September.

Building our fifth boat.

Reach Lynn Canal.

In addition to the physical obstacles to be encountered on the long route above outlined, some anxiety was caused by reported Indian troubles on the Yukon. We heard a most circumstantial account of these from a couple of miners who followed us in to Dease Lake, the report being that the hostile Indians had retreated up the Pelly. As it was impossible either to confirm or refute these reports without practically abandoning the scheme of work, it was determined to proceed according to the original arrangement. On reaching the mouth of the Lewes we ascertained that the story was entirely false, but it had none the less kept us in a state of watchfulness during a great part of the summer.

Reported Indian troubles

Main Geographical Results.

Geographical data obtained.

The main geographical results of the Yukon expedition, in so far as those are covered by the present report, are best shown by the accompanying maps, which may be compared with previous maps of the same region. Mr. Ogilvie's instrumentally measured line from the head of Lynn Canal to the intersection of the Yukon or Pelly by the 141st meridian, will form a sufficiently accurate base for further surveys. In addition to this we now have an instrumental survey of the Stikine from its mouth to the head of navigation (Telegraph Creek), which is connected with Dease Lake by a carefully paced traverse. This is continued by a detailed running- or track-survey following the lines of the Dease, Upper Liard and Pelly rivers, and connecting with Mr. Ogilvie's line at the mouth of the Lewes, the total distance from the mouth of the Stikine to this point, by the route travelled being about 944 miles. Adding to this the distance from the mouth of the Lewes back to the coast at the head of Lynn Canal (377 miles), the entire distance travelled by us during the exploration amounts to 1322 miles. This, taken in connection with the coast-line between the Stikine and Lynn Canal, circumscribes an area of about 63,200 square miles, the interior of which is still, but for the accounts of a few prospectors and reports of Indians, a *terra incognita.* The same description,

Length of route traversed.

with little qualification, applies to the whole surrounding region outside the surveyed circuit, but much general information concerning the country has been obtained, which will facilitate further explorations.

Along the routes thus travelled numerous points have been carefully fixed in latitude by sextant observations, and a sufficient number of chronometer longitudes have been obtained by which to lay the whole down within small limits of error. Special attention was paid to the sketching and fixing of mountain topography in sight from the line of travel, and the approximate altitudes of a number of the more prominent peaks was ascertained. Positions fixed.

No reference is made here to the further work carried out by Messrs. Ogilvie and McConnell in 1888, which will, as above stated, be separately reported on.

Orography and General Features.

The region traversed by the routes just mentioned, including the extreme northern part of British Columbia and the southern part of the Yukon district (as previously defined), is drained by three great river systems, its waters reaching the Pacific by the Stikine, the Mackenzie, (and eventually the Arctic Ocean,) by the Liard, and Behring Sea, by the Yukon. The south-eastern part of the region is divided between the two first named rivers, whose tributary streams interlock, the Stikine making its way completely through the Coast Ranges in a south-westerly direction, while the Liard, on a north easterly bearing, cuts across the Rocky Mountains to the Mackenzie valley. The watershed separating these rivers near Dease Lake has a height of 2730 feet, and both streams may be generally characterized as very rapid. Drainage system.

To the north-westward, branches of the Stikine and Liard again interlock with the head-waters of several tributaries of the Yukon, which here unwater the entire great area enclosed on one side by the Coast Ranges, on the other by the Rocky Mountains. As the general direction of this line of watershed is transverse to that of the main orographic ridges of the country, it will probably be found, when traced in detail, to be very sinuous. The actual watershed, between the Liard and Pelly, on our line of route, was found to have an elevation of 3150 feet, but it is, no doubt, much lower in the central portion of the region between the Rocky Mountains and Coast Ranges. Watershed.

To the north of the Stikine, at least one other river, the Taku, cuts like it completely across the Coast Ranges, but its basin is comparatively restricted and little is yet known of it.

It will be noticed, that while the several branches of the Yukon con- Courses of Rivers.

form in a general way to the main orographic axes, the Stikine and Liard appear to be to a large degree independent of these, and to flow counter to the direction of three mountain ranges.

Relief of the region.

The region as a whole, being a portion of the Cordillera belt of the west coast, is naturally mountainous in general character, but it comprises as well important areas of merely hilly or gently rolling country, besides many wide, flat-bottomed river-valleys. It is, moreover, more mountainous and higher in its south-eastern part—that drained by the Stikine and Liard,—and subsides gradually, and apparently uniformly, to the north-westward; the mountains at the same time becoming more isolated and being separated by broader tracts of low land. The general base-level, or height of the main valléys, within the Coast Ranges, thus declines from about 2500 feet, to nearly 1500 feet at the confluence of the Lewes and Pelly rivers, and the average base-level of the entire region may be stated as being a little over 2000 feet.

Trend of ranges.

Disregarding minor irregularities, it is found that the trend of the main mountain ridges and ranges shows throughout the entire region here described a general parallelism to the outline of the coast. In the south-eastern and more rugged tract, the bearing of such ranges as are well defined is north-west by south-east, while beyond a line which may be drawn between the head of Lynn Canal and Frances Lake the trend gradually changes to west-north-west.

The Coast Ranges.

The Coast Ranges, with an aggregate average width of about eighty miles, the whole of which is closely set with high, rounded or rugged mountains, constitutes the most important orographic uplift in the entire region, and here reproduces geographically and geologically the features characteristic of it in the more southern portion of British Columbia. Beyond the vicinity of Lynn Canal, this mountain axis runs behind the St. Elias Alps, ceasing to be the continental border, and may be said to be entirely unknown, as any indications of mountains which have appeared on this part of the map are purely conjectural. Notwithstanding the great width of the Coast Ranges, it is not known that any of their constituent mountains attain very notable altitudes, but it is probable that a great number of the peaks exceed a height of 8000 feet. These ranges are composed of very numerous mountain ridges, which are not always uniform in direction, and, so far as has been observed, there is no single culminating or dominant range which can be traced for any considerable distance.

Rocky Mountain Ranges.

The mountain axis next in importance to that of the Coast Ranges, is that which forms the water-parting between the Upper Liard and Yukon, on one side, and the feeders of the main Mackenzie River on the other. This represents the north-western continuation of the Rocky Mountains proper. Its eastern ridges were touched on during

the present exploration in the vicinity of Frances Lake and the head waters of the Pelly River, and are there designated on the map as the Too-tsho Range. This forms, so far as has been ascertained, the culminating range of a number of more or less exactly parallel ridges, and summits in it attain heights of from 7000 to 9000 feet. It has, however, been traced to a comparatively limited distance only, and it appears probable that a very complicated mountain system remains to be worked out in this portion of the region.

A third notable mountain axis, which I have designated on the map as the Cassiar Range, is cut through by the Dease River in its upper course, and further to the north-westward appears to form the line of water-parting between the tributaries of the Upper Liard and those of the branches of the Yukon. Peaks near the Dease, in this range, exceed 7000 feet, but it is probable that none much exceed 8000 feet, and that the range in a general way becomes lower to the north-westward. Cassiar Range.

In the north-western and less elevated moiety of the region, the mountain ranges and ridges are in general lower and become discontinuous and irregular, or while retaining a general parallelism, assume an overlapping or echelon-like arrangement.

In each of these mountain chains above described granitic rocks appear in greater or less force, as more fully noted on succeeding pages. In the intervening and subordinate mountain systems of the south-east, granitic axes are not found and do not exist as prominent features. Granitic rocks.

Scarcely anything is known of the character of the country drained by the Macmillan, Stewart and White rivers, but it is probable that the basins of the two first-named streams closely resemble that of the Upper Pelly, which is described in following pages. Miners who have ascended the Stewart for a hundred miles or more, report the existence of a continuous range of mountains of considerable height, which runs parallel to the river on the north, from a point about fifty miles from its mouth onward. The absence of tributaries of any size along the south-west side of the Lewes below the Tahk-heena, with the general appearance of the country in that direction, so far it has been overlooked, seems to show that the basin of the upper portion of the White River must be comparatively low, and situated as it is within the St. Elias Alps, this country must possess most remarkable features, both geographically and from a climatic point of view, and well deserves exploration. It would further appear to be nearly certain that the sources of the Tanana River are to be looked for in this district, well to the east of the 141st meridian. Orography of neigbouring regions.

The topographical features of the entire region here described have been considerably modified by the events of the glacial period, and the Effects of the glacial period.

changes produced at that time have more particularly affected the drainage-basins and the courses of the various streams. The valleys and lower tracts of country are now more or less completely filled or covered by extensive deposits of boulder-clay, gravel, sand and silt laid down during that period. To these deposits are due the flat floors of the larger valleys, and also to a great extent the appearance which the more irregular mountain regions present of being partly submerged in level or rolling plains. Many changes in direction of flow in river-valleys have doubtless also been produced during this period, though most of these yet remain to be worked out. The general result has been to produce systems of "inconsequent" drainage wherever the natural slopes of the country are easy and the limiting ranges irregular. Most of the rivers at the present day have done little more than cut out new channels in the glacial *débris*, touching only here and there upon the subjacent rocky floor.

Sources of the Yukon and Nomenclature.

Confused nomenclature.

Such particulars as have been ascertained relative to the various rivers examined in the course of the exploration, are given in a subsequent part of this report. As, however, some confusion has arisen in respect to the nomenclature of the Yukon and its tributaries, and erroneous statements have been made as to the "source" of the river, it may be appropriate here briefly to note the facts in the case in so far as I have been able to ascertain them. Further details of the early exploration of the river are given on page 136 B.

First exploration of Yukon.

The estuary of the Yukon appears to have been first explored by the Russian, Glasunoff, in 1835 to 1838, and the river was then named by the Russians the Kwikhpak, which name, according to Mr. W. H. Dall, is in reality that of one of the channels by which it issues to the sea. The lower part of the river, however, continued to be known under this name for a number of years, and it is so called on the (Russian) map of Lieut. Zagoskin, made from reconnoisance surveys which, in 1842-43, he carried up as far as Nowikakat. The mouth of the river is shown on Arrowsmith's map of 1850, but is there nameless.

Origin of the name.

The name Yukon was first applied in 1846 by Mr. J. Bell, of the Hudson Bay Company, who reached the main river by descending the Porcupine, and called it by what he understood to be its Indian appellation. The head-waters of one of the main tributaries of the Yukon had previously been attained by Mr. R. Campbell (also an officer of the Hudson Bay Company) in 1840, and in 1850 he descended the river as far as the mouth of the Porcupine, naming the whole river thus traversed the Pelly, and naming also the Lewes, White and Stewart rivers, as well

as numerous smaller tributaries. Campbell's nomenclature and his sketch of the river appear on Arrowsmith's map published in April, 1854, and Campbell practically established by his journey the identity of his Pelly River with the Kwikhpak of the Russians. The connection between the two is given by a sketch (shown in broken lines) on the map just cited, on which also the mouth of the Tanana River (under the name Mountain-men River) is shown, and other details represented with reasonable accuracy. The sketch of the river below the mouth of the Porcupine appears to have been due to the Hudson Bay Company's traders, who, before Campbell had communicated his geographical information in London (in 1853), had already met the Russian traders at the mouth of the Tanana. Much later, in 1863, I. S. Lukeen, of the Russian Trading Company, ascended the river to the Hudson Bay post, Fort Yukon, at the mouth of the Porcupine.* Connection of Yukon and Kwikhpak.

The name Yukon does not appear at all on Arrowsmith's map of 1854, that of the Pelly standing for the whole length of the river explored by Campbell, but since that date the term Yukon has gradually become applied to the main river. The next map in order of publication in which original data are employed is, I believe, that accompanying Mr. Whymper's paper of 1868, in the Journal of the Royal Geographical Society,† which is also reproduced in his book, Travels in Alaska and on the Yukon (1869). His general map gives the name Pelly for the whole river above the mouth of the Porcupine, "Kwich-Pak or Yukon," for the lower part. In his large-scale map, on the same sheet, the river above the Porcupine is named the Yukon or Pelly. Whymper refers to the river as the "Yukon (or Pelly) as it has long been called on our maps."‡ In the United States Coast Survey map dated 1869§ the main river between the Porcupine and Lewes is definitely named the Yukon; but in the map accompanying Raymond's official report (1871) this name is again confined to the river below the Porcupine, and the statement is made in the report (p. 21) that from Lake Labarge to Fort Yukon the river is called the Lewes. Usage on subsequent maps.

* By a singular oversight, Mr. W. H. Dall states in the first part of his work, Alaska and its Resources 1870 (p. 4), that "the identity of the Yukon [Pelly] River with the so-called Kwikhpak of the Russians" remained to be established when the explorations of the Telegraph Survey commenced on the river in 1865, while giving the credit of this achievement to Lukeen on a subsequent page (p. 277). Raymond repeats this error in his Report of a Reconnoissance of the Yukon River (1871). Mr. Dall's work above cited constitutes a veritable mine of information on the subjects of which it treats, and is frequently referred to in the sequel. Where, therefore, as in the above case, criticisms are offered, it is in no spirit of detraction.

† Vol. xxxviii.

‡ *Op. cit.*, p. 223.

§ In United States Coast Survey Report for 1867 the same nomenclature is adopted, as it is also in the map accompanying Mr. Dall's Alaska (1870), in the Ethnological map of Alaska by the same author (1875), and in most later maps. These, however, do not embody any original data for this region.

Further confusion of nomenclature.

Much later, Lieut. Schwatka, in the maps accompanying the official report of his explorations of 1883 and in other maps elsewhere published, in defiance of the fact that the name of the Lewes had a published priority of thirty years, erased it completely, extending the name Yukon so as to include under that designation the Lewes River. This extension of the name Yukon appears to be justified by Lieut. Schwatka on the ground that the Lewes is the larger branch at its confluence with the Upper Pelly. As elsewhere stated, this is no doubt true, but from what is now known of the Upper Pelly, that river is almost certainly the longer, its sources are furthest removed from the mouth of the Yukon and its course is more directly in continuation of its main direction than is the case with the Lewes. Granting, however, that the Lewes excelled in all these particulars, it would still, I believe, be unjustifiable to alter an old established name for the sole purpose of giving to a river a single name from its mouth to its source. In any case it is incorrect to state that the Yukon (Lewes) rises in Lake Lindeman, or streams flowing into it, as is done by Schwatka, for by far the greater part of the water of the river enters by the Taku arm of Tagish Lake.

With respect to the substitution of the name Yukon for that of Pelly on the portion of the river between the Porcupine and Lewes, it is simply a question of well established priority *versus* use. It is possibly a matter of small importance which shall be employed in future, but no valid excuse can be offered for the attempt to substitute any new name for that either of the Lewes or Pelly above the site of old Fort Selkirk.

True sources of the Yukon.

From the point of view of the physical geographer, and apart from the question of nomenclature, the position of the furthest source of the great Yukon River is, however, an interesting subject of enquiry; though it may yet be some years before we are in possession of sufficient information to settle this question definitely. It may be confidently assumed that this point is to be found by following up either the Pelly or the Lewes from their confluence at the site of old Fort Selkirk. As already stated, the Lewes there carries the greater volume of water, but draining as it does a considerable length of the humid Coast Ranges, which bear throughout the year great reserves of snow and numerous glaciers, it does not compare on terms of equality with the Upper Pelly, which unwaters a region relatively dry. Whether reckoned by size or distance from its mouth, the source of the Lewes must be placed at the head waters of the Hoṭilinqu River,* explored by Byrnes, of the Telegraph Survey, in approximate latitude 59° 10′,

* The Tes-lin-too occupies the main orographic valley above its confluence with the Lewes, but is smaller than the Lewes, and besides doubles back on its course, as is shown on the map.

longitude 132° 40′. In regard to the Pelly, it is not yet absolutely certain that the Pelly proper rises further from the common point at Fort Selkirk than its great branches, the Macmillan and the Ross rivers, but it is highly probable that it will be found to do so.

Comparison of tributaries.

With the above facts premised, we may compare the respective distances of assumed or probable sources of the Yukon as below, the distances being in each case measured in a straight line from the common point at Fort Selkirk:—

Fort Selkirk to summit of Chilkoot Pass, source according to Schwatka (position fixed)	224	miles.
" " to head of Hotalinqu River of Telegraph Survey (position approximate)	294	"
" " to "Pelly Banks" (position fixed)	213	"
" " to head of Pelly Lakes (above "Pelly Banks," according to Campbell's sketch)	276	"

The upper lake on the Pelly must be fed by a considerable stream or streams, the addition of the length of which, if known, would add considerably to the last of the above distances.

Size of the river.

I must confess to having been somewhat disappointed in the size of the Pelly or Yukon where we saw it below the confluence of the Lewes. The river is there, when undivided by islands, about 1700 feet only in width, with a maximum depth scarcely exceeding ten feet when at a stage which may be considered as its approximate mean. It appeared to me to be about equal in size and velocity to the Peace River at Dunvegan and Mr. Ogilvie, who is also familiar with the Peace, concurred in this estimate. Below this place the river, of course, receives a number of important tributaries, but at any fairly comparable point on the two rivers I believe that the Mackenzie must far exceed the Yukon in volume. Numerical data on this point are unfortunately still almost entirely wanting, but the comparison of the drainage-areas of the two rivers, according to the latest available information, strongly bears out the statement just made, that of the Yukon being 330,912 square miles as against 677,400 square miles in the case of the Mackenzie.* In other words, the drainage area of the Mackenzie is more than double that of the Yukon, while nothing is known to show that the mean annual precipitation over the two areas, as a whole, differs very greatly. Exaggerated statements which have been made, to the effect that the Yukon discharges a volume of water approaching that of the Mississippi, appear to carry their own refutation in the fact that the basin of the latter river has an area of no less than 1,226,000 square miles.

Comparison with Mackenzie River.

* Of the area drained by the Yukon, about 150,768 square miles are in Canadian, 180,144 square miles in United-States Territory.

Discharge of rivers.

Some attempt was made by us to gage the flow of several of the rivers in the Yukon basin, as more fully stated further on. The discharge of the several rivers above the site of the old Fort Selkirk may be roughly summarized as follows. The figures given in heavy type are derived from measurements more or less approximate, the others are based merely on comparisons made by eye and without any attempt to cross-section the streams. The scheme may, however, serve to give a general idea of relative dimensions. All the figures represent cubic feet per second and refer to the latter part of the summer, when the rivers may be assumed to be at their mean height. In common with all the streams of the interior region these are highest in the early summer and lowest toward the end of the winter.

Pelly River, at "Pelly Banks"	**4,898**
Ross River, at mouth	4,898
Macmillan River, at mouth	9,796*
Tes-lin-too, at mouth	**11,436**
Lewis River, above confluence with last	**18,664**
Big Salmon	**2,726**
Total thus accounted for	52,418
Pelly or Yukon at site of Fort Selkirk	**66,955**
Difference from above total, not accounted for	14,537

Upper Pelly and Lewes compared.

By adding two-thirds of the water thus not accounted for to the Pelly and one-third to the Lewes, to represent the flow of numerous smaller tributaries not enumerated, the discharge of these two rivers above Fort Selkirk will stand thus :—

Lewis	37,672
Pelly	29,283
Total as above	66,955 †

* The discharge of the Ross is taken as equal to that of the Pelly at "Pelly Banks," that of the Macmillan as equal to the combined waters of the Pelly and Ross.

† For the purpose of comparison, the following extract from a table of various rivers, contained in the General Report of the Minister of Public Works for the fifteen years from 1867 to 1882, is quoted :—

NAMES.	Area of drainage in square miles.	Length in miles.	Discharge in cubic feet per second. Low Water.	Mean.	High Water.
Mississippi	1,226,000	4,400	447,200	....	1,270,000
St. Lawrence	565,000	2,600	....	900,000	....
Ganges	432,000	1,680	36,300	207,000	494,200
Nile	520,200	2,240	23,100	220,000	....
Thames	5,000	215	1,330	....	7,900
Rhone	38,000	560	7,000	21,000	204,000
Rhine	88,000	700	13,400	33,700	164,000
Ottawa (Grenville)	80,000	700	35,000	85,000	150,000

Navigable Waters and Routes of Travel.

Navigable rivers.

The numerous large and important rivers by which the Yukon district and the adjacent northern portion of British Columbia is intersected, constitute the principal routes of travel, and during the summer months render inter-communication comparatively easy. The Stikine is navigable by stern-wheel steamers for a distance of 138 miles, as more fully stated in a subsequent part of this report, where also details respecting the connecting trail to Dease Lake are given (pp. 46 B, 64 B). This constitutes the travelled route to the Cassiar mining district. A trail was, at one time, opened from Fraser Lake overland to Dease Lake by which cattle were driven through, but of late no travel has occurred on it (p. 89 B). The Dease River can scarcely be considered as navigable for steamers, though constituting a fairly good boat route (p. 91 B). The Upper Liard and Frances rivers, above the mouth of the Dease, are also passable for large boats, with occasional portages, but not so for steamers (p. 102 B). The difficulties of the Lower Liard, however, are such as to render it an undesirable route, even for boats, and scarcely suitable as an avenue of trade between Cassiar and the Mackenzie. Numerous tributary streams in this district may also be ascended by boat or canoe for considerable distances, though with many interruptions from rapids and bad water.

Possible railway route.

Communication may easily be established by railway from the mouth of the Stikine to the centre of the Cassiar district and beyond, when this shall be called for, and it is probable also that this district might, without difficulty, be connected by rail with the more southern portions of British Columbia by one or more routes of which the main outlines can already be indicated. Following the river-valleys, by a route practicable for a railway, from Rothsay Point at the mouth of the Stikine to the mouth of the Dease, the distance is found to be 330 miles. Thence to Fort Simpson on the Mackenzie, is a further distance of 390 miles, making the total distance by this route, from the Pacific to the navigable waters of the Mackenzie about 720 miles only.

Taku River and trails.

Little is yet known of the Taku River, but the Indians ascend it in canoes to a point at a distance of about eighty miles from the head of Taku Inlet, and Indian trails lead south-eastward from this vicinity to the Tahl-tan, eastward to Tes-lin Lake and north-eastward to the lakes near the head of the Lewes. From what has been ascertained of these, it is probable that it would not be difficult to construct a trail suitable for pack-animals, if not a waggon road, from the vicinity of the head of navigation on the Stikine to these lakes connecting with the navigable waters of the Lewes.

Tributaries of Yukon.

The rivers draining the Upper Yukon basin, have in general lower grades, and afford better navigable water than those above referred to, and are in consequence likely to prove of greater importance in connection with the exploration and development of the country. The distance to which they may be respectively ascended by boat or canoe, has as yet been determined in only a few cases.

Navigable lengths of rivers.

It may, however, be stated that the Yukon is continuously navigable for small steamers from its mouth, on Behring Sea and following the Lewes branch, to Miles Cañon. Thence, after an interruption of about three miles, to the head of Bennett Lake and to an additional considerable—though not precisely determined distance—by the waters extending south-eastward from Tagish Lake (p. 165 B). The Tes-lin-too is probably navigable for stern-wheel steamers for a hundred and fifty miles or more from its mouth, (p. 154 B) while the Tahk-heena and Big Salmon rivers may probably both be ascended by steamers of the same class for some distance. From the site of old Fort Selkirk, again, the Pelly might be navigated by small steamers of good power to within about fifty miles of the site of old Fort Pelly Banks, (p. 133 B) and the Macmillan branch is also navigable for a considerable, though not ascertained distance (p. 129 B). The same may be said of the Stewart River, but White River is, so far as known, very swift and shoal.

Aggregate length of navigable waters.

The total length of the waters which may be utilized for navigation by light stern-wheel steamers on the main river and its branches to the east of the 141st meridian or Alaskan boundary, measured in straight lengths of fifty miles, is therefore at least 1000 miles, and following the sinuosities of the various streams would be very much greater. This does not include the Porcupine River, and with the exception of the single break above referred to on the Lewes, forms a connected system, all parts of which lie to the east of the above meridian. If the upper portion of these rivers, above the first obstacles to such navigation, were included, the total here given would doubtless be greatly added to.

Means of access to Yukon District.

At the present moment but three routes of access to the Yukon district are employed. (1). That of the portage by the Chilkoot Pass from the head of Lynn Canal to the navigable waters of the Lewes. (2). That from Peel River, near its confluence with the Mackenzie by portage to La Pierre's House on a branch of the Porcupine. (3). That from Behring Sea by the main river. The first is that almost exclusively used by the miners, the second is employed only by the Hudson Bay Company, and the last is that of the Alaskan traders.

There are now three small stern-wheel steamers on the lower river, which ascend each year as far as the trading post at Forty-mile Creek,

bringing the greater part of the goods used in trade with the Indians and for the supply of miners. It is not possible, however, for miners to reach the scene of their operations by this route in time to make a season's work, and the chances of reaching or leaving the Yukon mouth are few and precarious. Particulars relating to the Chilkoot Pass and Lewes River will be found on pages 173 B, 174 B. The character of the pass is such that it would scarcely be possible to construct a useful trail across it for pack-animals, but the White Pass appears to offer a better opportunity for making a trail or road which, if constructed, would render the entire region much more easy of access. Another route, also leading from the head of Lynn Canal to navigable water connecting with the Lewes, is that by the Chilkat Pass. This was formerly much employed by the Indians, but entails a much longer land carriage, one which is said to occupy the Indians for twelve days when carrying packs, as against two days of packing by the Chilkoot Pass.

Indian routes.

The Indians inhabiting the region to the south and east of the site of old Fort Selkirk are poor boatmen and follow the various rivers in the course of their periodic journeys to a very limited extent. Most of their travelled routes appear, indeed, to run nearly at right-angles to the direction of drainage, the rivers being crossed in summer on rafts, the remains of which may frequently be observed. In travelling thus they carry their entire small camping outfit on their backs.

Climate, Agriculture and Flora.

General character of climate.

While the available information as to the climate of the northern portion of British Columbia and the Yukon district is necessarily as yet very imperfect, its general features are sufficiently obvious, repeating as they do those met with in the similarly circumstanced region to the south, with such modification as is produced by their higher latitude. The coast and coastward slopes of the Coast Ranges constitute a belt of excessive humidity and great precipitation, with somewhat equable temperatures, while the interior region to the eastward of these ranges is relatively dry, with a temperature of extremes.* In the interior, however, the climate is largely influenced by the altitude of each particular district, and in consequence of the general lowering of the country beyond the 60th parallel (constituting the north line of British Columbia), it is certain that the climatic conditions are there much more favorable than in the Cassiar district.

Regions of heavy and light rainfall.

The mean annual temperature of the coast region is considerably higher than that of the interior; yet, in consequence of the great

* A mean of the total annual precipitation for Fort Tongass, Wrangell and Sitka gives a general mean for the coast of 86·81 inches.

depth of the snow-fall and persistently clouded character of the skies, the Coast Ranges are found to support numerous and massive glaciers, while these are almost or altogether absent in the Cassiar Mountains, in the mountains about Frances Lake and in the other ranges seen by us in the interior. The heavy accumulation of snow upon the Coast Mountains and in their valleys, retards the progress of spring, as is very clearly evidenced on the Stikine, and explained more fully elsewhere. (p. 58 B). The depth of snow in winter continues to be inconsiderable or moderate, at least as far down the Pelly (Yukon) as the mouth of Stewart River and Forty-mile Creek, while at Nulato, on the lower river and in a similar latitude, but 500 miles further west, the depth of snow from April to November is said to average eight feet and often to reach twelve feet.* Mr. Dall also writes: "The valley of the Lower Yukon is somewhat foggy in the latter part of summer; but as we ascend the river the climate improves, and the short season at Fort Yukon is dry, but pleasant, only varied by an occasional shower." Relatively to the country of the Upper Yukon basin, the advent of spring is much retarded in the country to the west, and it is stated that on the river below Nulatto alder buds were found just opening and tender leaves beginning to appear on the 4th of June. These and other facts seem to show conclusively, that in the absence of a continuous mountain barrier in that region, the humid winds of the Pacific are enabled to push eastward a long way up the Yukon valley, carrying with them the belt of heavy snow-fall, which ceases to be conterminous with the Coast Mountains, as it is to the south-eastward.

Progress of spring.

Dry belts.

As in the more southern parts of British Columbia, the dryest country is found to occur in a belt bordering the eastern or lee side of the Coast Ranges, and this phenomenon recurs, though in a less marked degree, in connection with each of the well-defined mountain ranges of the interior. Thus a region of greater humidity is found near Dease Lake, on the western side of the Cassiar Mountains, with a dry belt on the east side of the range; while humid conditions, with recurrent showers in summer, characterize the district in the vicinity of Frances and Finlayson lakes. Further illustrations of this fact, with other climatic observations, will be found in the body of this report and in Appendix VI.

Summer and winter winds.

A noteworthy circumstance in connection with the Stikine valley, the passes leading from the head of Lynn Canal, and doubtless in all the low gaps in the Coast Ranges, is the change in direction as between the summer and winter winds. During the summer strong winds blowing up these valleys inland, are of very frequent occurrence and they commonly freshen in the afternoon and die away toward night. In

* Alaska and its Resources. W. H. Dall, 1870, p. 437.

the winter months the conditions are precisely reversed, the strongest winds blowing seaward. The summer winds are doubtless homologous with the sea breezes observed in many other regions, while the direction of the winter winds probably depends on the existence of a persistent anti-cyclonic area in the interior during that season.

Temperatures of coast and interior.

The temperature of Wrangell, just off the mouth of the Stikine, may probably be taken as fairly representative of that of the coast in these latitudes. For the interior region, here particularly treated of, we are unfortunately without a series of thermometer readings extending even over a single year, but some idea of its climate may be formed from that of Fort Yukon, which is, however, situated far to the north, almost exactly on the Arctic circle. The mean seasonal temperatures for these two stations may be compared as below.*—

	Wrangell.	Fort Yukon.
Spring	40.4	14.6
Summer	57.1	56.7
Autumn	43.0	17.4
Winter	28.3	—23.8
Year	42.2	16.8

Comparison with Russia.

In the central provinces of European Russia the thermometer descends to —22° and —31°, and occasionally even to —54°, in the winter months, but rises at times to 104° and even to 109° in summer. The rain-fall is small, varying from sixteen to twenty-eight inches, the maximum precipitation taking place during the summer months, and not, as in western Europe, in the winter, while the months of advanced spring are warmer than the corresponding months of autumn.† So far as our information goes, the above statement might almost be adopted as characterizing the climate of the southern half of the Yukon district.

Crops and cultivation.

At Telegraph Creek and in its vicinity on the Stikine, to the east of the Coast Ranges (lat. 58°), wheat, barley and potatoes are successfully grown with the aid of irrigation. Their cultivation has so far been attempted on a limited scale only, on account of the want of any market, and wheat has been grown only experimentally, as it cannot, like barley, be employed for feeding pack-animals. None of these crops can be successfully grown or ripened on the coastward side of the mountains. At Fort Yukon (situated, as above noted, on the Arctic circle) Mr. Dall states he was informed that barley had once or twice been tried in small patches and had succeeded in maturing the grain, though the straw was very short.‡ A few cattle were also

* From the United-States Coast Pilot, Alaska, Part I, 1883, p. 269.
† Encyclopedia Britannica, vol. xxi, p. 67.
‡ *Op. cit.*, p. 441.

kept here at one time, when the post was in the possession of the Hudson Bay Company. Petroff, in his Census Report on Alaska, endeavors to discredit Dall's statement as to the growth of barley at this northern point, but I am fortunately in possession of independent evidence as to its accuracy, the late Mr. James Anderson, of the Hudson Bay Company, having noted in an official report on the district that both potatoes and barley have been grown at the fort.

Conclusions as to possible agriculture

Taking into consideration all the facts which I have been able to obtain, as well as those to be derived from an examination of the natural flora of the country, and the observed advance of vegetation, which, in the absence of actual experiments, are capable of affording valuable data, I feel no hesitation in stating my belief that such hardy crops as barley, rye, turnips and flax can be successfully cultivated in the Yukon district as far north as the former position of Fort Selkirk, near the 63rd parallel, or in other words about 1000 miles north of Victoria. Taken in conjunction with the physical features of the region, this means, that chiefly within the drainage area of the Yukon, and for the most part to the north of the 60th parallel, there exists an area of about 60,000 square miles, of which a large proportion may, and doubtless in the future will—be utilized for the cultivation of such crops, and in which cattle and horses might be maintained in sufficient number for local purposes, without undue labor, as excellent summer grazing is generally to be found along the river-valleys and natural hay-meadows are frequent. I do not maintain that the country is suitable for immediate occupation by a large, self-supporting agricultural community, but hold that agriculture may before many years be successfully prosecuted, in conjunction with the natural development of the other resources of this great country, of which by far the most valuable portion lies to the east of the line of the Alaskan boundary.

Trees.

A note on the distribution of the various species of trees and on that of some of the herbaceous plants forms a separate section of this report (Appendix I), while in Appendix III, Prof. Macoun gives a list of the plants collected.

Timber.

Remarks on the quantity and quality of timber along the various routes are given under the local headings. It may suffice here to state, in this connection, that the country is generally wooded,* and that in all portions of it, in valleys and on low lands, there is an abundance of white spruce, of fair to good quality, well suited for purposes of construction. The other species of trees present are of inferior economic importance.

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* No areas of *tundra* or frozen morass, such as are stated to be characteristic of the country of the Lower Yukon, were found in the region here reported on.

Fauna.

The fauna of the region traversed by us, does not differ notably from that of other parts of the northern country which are already moderately well known. There are, no doubt, many interesting points yet to be determined in respect to distribution, but our opportunities for obtaining information of this kind were very limited. The smaller black-tailed deer (*Cariacus Columbianus*) occurs on the islands of the southern portion of Alaska and the adjacent mainland coast, but is nowhere found on the inland side of the Coast Ranges. The mountain goat is moderately abundant in the Coast Ranges, and is also found in the mountainous inland regions, probably throughout. The big-horn or mountain sheep occurs, together with the last-mentioned animal, on the mountains about the head of the Lewes and other parts of the inland spurs of the Coast Ranges, but does not inhabit the seaward portions of these ranges. It is also found generally in the mountains of the interior, including the Rocky Mountains. **Larger animals noted.**

The moose is more or less abundant throughout the entire inland region, and together with the caribou, which is similarly ubiquitous, constitutes a great part of the food of the Indians. We found the moose particularly plentiful along the Upper Liard River, and it is stated that the country drained by the White River is noted among the Indians as a moose and beaver region. The caribou is everywhere common, but is scarcely seen in the valleys or lower country during the summer, when it ranges over the high, alpine moors and open slopes of the mountains.

The black and grizzly bears roam over the entire region and are often seen along the banks of the rivers in the latter part of the summer when dead or dying salmon are to be obtained with ease. Wolves are not particularly abundant, but the cross-, black- and silver-fox are more than usually common.

The smaller fur-bearing animals, being similar to those found generally in the northern parts of the continent, do not require separate enumeration. The entire Upper Yukon basin, however, yields furs of exceptionally high grade. Some notes as to the quantity of furs annually obtained from the region will be found in a subsequent paragraph (p. 28 B). **Smaller fur-bearing animals.**

Among a few skins brought back by us, is that of a mouse which Dr. C. H. Merriam has found to be a new species, and has described under the name of *Evotomys Dawsoni*.*

The salmon ascend the Lewes River as far as the lower end of Lake Marsh, where they were seen in considerable numbers early in Sep- **Salmon.**

* American Naturalist, July, 1888.

tember. They also, according to the Indians, run almost to the headwaters of the streams tributary to the Lewes on the east side. Salmon also run up the Pelly for a considerable distance above the mouth of the Lewes, but their precise limit on this river was not ascertained. The lakes and rivers generally throughout the country are well supplied with fish, and a small party on any of the larger lakes would run little risk of starvation during the winter, if provided with a couple of good gill-nets and able to devote themselves to laying in a stock of fish in the late autumn.

Other fishes. As might be anticipated from the interlocking of streams tributary to the Mackenzie and Yukon in this region, the fishes in both drainage-areas appear to be identical, so far as I was able to observe, with the exception of the salmon, which is, of course, confined to the Yukon tributaries. The principal fishes noticed are white-fish (*Coregonus Nelsoni*), lake trout (*Salvelinus Namaycush*), grayling (*Thymallus signifer*), pike (*Esox lucius*), and sucker (*Catostomus catostomus*). The names above given are on the authority of Dr. T. H. Bean, of the U. S. Commission of Fish and Fisheries, who has very obligingly examined for me the photographs of fishes which were taken. No photograph, unfortunately, was obtained of the salmon seen on the Lewis, etc., but Dr. Bean informs me, from my description of its size, that he has little doubt it was the king salmon, *Oncorhynchus chuicha*.

Insects. Appendix IV includes a list by Mr. James Fletcher, F.R.S.C., of the species of insects collected

Mining and Minerals.

Placer gold-mining. Mining has so far been confined within the Cassiar district and in the Upper Yukon basin to the working of gold placers, and in the latter, almost entirely to river-bar mining, the inception of which indeed dates only from 1880. Particulars with reference to the rich creeks of Cassiar will be found on page 83 B, and facts relating to the rivers tributary to the Yukon on page 181 B. Almost all the large streams which have been prospected in the Yukon basin have been found to yield placer gold in greater or less quantity and the aggregate length of the rivers thus already proved to afford gold is very great, but little has been done toward the examination of their innumerable smaller feeders. Similar river-bar mining on the Stikine and Liard rivers proceeded the discovery of the smaller creeks in which the richer deposits of "heavy" gold were obtained, and a few miles in length each of Dease, Thibert and McDame creeks produced the greater portion of the $2,000,000 worth of gold credited to Cassiar in 1874 and 1875. Discoveries similar to these may be expected to occur at any time in

the Yukon district, the generally auriferous area of which already proved is very much greater than that of Cassiar. Scarcely anything has been done as yet even in the Cassiar district toward the search for or proving of metalliferous veins, and practically nothing in the Yukon district, but there can be no reasonable doubt that such deposits exist.* The present activity in mining enterprise in the southern part of British Columbia will, before long, spread to this northern region also, and then, if not before, its valuable character as a portion of the metalliferous belt of the continent will be realized.

Metalliferous veins.

The Yukon district with the northern part of British Columbia, measured from the vicinity of Dease Lake to the intersection of the Pelly (Yukon) with the 141st meridian comprises a length of over 500 miles of the Cordillera belt of the west, which, wherever it has been examined, has been found rich in minerals and particularly in the deposits of the precious metals. The width of this particular part of the Cordillera belt is also great, as it appears, so far as our explorations have gone, to extend from the coast to the eastern ranges of the Rocky Mountains in the vicinity of the Mackenzie River. This portion of the Cordillera region, together with that of the more southean part of British Columbia, gives an aggregate length of between 1200 and 1300 miles, almost exactly equal to the length of the same metalliferous belt contained by the United States, and in all probability susceptible of an eventual mining development equally great.

Importance of Metalliferous belt.

In the northern districts here reported on, it is true that the winter climate is a severe one, rendering the working season for ordinary placer-mines short and likely also to present some special difficulties in the way of "quartz mining." There is, however, on the other hand an abundance of wood and water, matters of great importance in connection with mining, and means of communication once provided, mining operations should be carried on here at less cost than in dry and woodless regions such as are great portions of Arizona.

Bearings of climate on mining.

Statistics of the former and present gold production of Cassiar are given in connection with that district, on page 82 B. It is difficult if not impossible to arrive at even an approximate statement of the total amount of gold which has been so far afforded by the Yukon district, but from such enquiry as I was able to make in 1887, I estimated the value of gold obtained in that year at a minimum of $60,000; the number of men engaged in mining at 250.

Statistics of gold.

A specimen of asbestus (chrysotile) being part of a small vein of that material about half an inch in thickness, has been brought from

Asbestus.

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* A specimen of galena obtained from McDame Creek, Cassiar, was found to contain 75 ounces of silver to the ton (see p. 86 B) and of seven specimens of vein stuff collected by us on the Upper Pelly and Lewes, five proved to contain distinct traces of gold on assay.

the Stewart River, and the occurrence of serpentine in large mass elsewhere, tends to show that workable asbestus deposits may yet be found in the region.

Platinum.

Platinum is found in small quantities along all or nearly all the tributaries of the Yukon, in association with the gold. It has also been observed in the Cassiar district.

Fur Trade.

Exports of furs.

Gold and furs are at present the only articles of value derived from the great region here referred to as the Yukon district. It is impossible to secure accurate information as to the value of furs annually obtained, but sufficient is known to show that it must be very considerable. Petroff, in his report, states that the total annual value of the furs shipped by the Yukon probably does not exceed $75,000, * and it is known that a great, if not the greater, portion of this total is derived from the region lying east of the 141st meridian. Dall states, that at the date of his visit (1867), the value of furs annually obtained at Fort Yukon, then maintained by the Hudson Bay Company, was not less than $50,000. Captain Raymond notes that the total number of skins collected in 1869, at this place, was stated at 10,000, but adds that he believes this estimate to be excessive.† Practically the whole of these may be regarded as having been brought by Indians from the region east of the Alaskan line. An approximate estimate of the furs derived from Canadian territory and taken down the Yukon, obtained from Mr. François Mercier, who spent many years trading on the river, places the annual value at about $27,000. The annual catch is made up, according to the same authority, about as follows:—

Beaver	1200 to 1500	skins.
Cross fox	100	"
Black fox	100	"
Red fox	300	"
Bear	300	"
Marten	4000	"
Otter	200	"
Mink	2000	"
Lynx	600	"
Wolverine	150	"
Wolf	100	"
	9350	"

* Report on the Population Industries and Resources of Alaska, p. 5, U. S. 10th Census, vol. viii.

† *Op. cit.* p. 115.

In addition, however, to the furs taken from the Yukon district by this route, the Hudson Bay Company obtains a large quantity of skins from their posts on the Porcupine, which reach the market by the Mackenzie River route. A certain number of skins derived from the country north of British Columbia is, further, annually traded at the little post at the mouth of Dease River, and taken out by the Stikine. A considerable quantity of furs also each year finds its way by the Chilkoot and Chilkat passes to the head of Lynn Canal, and some are brought down by the Taku River to the coast, though the greater part of these last is probably derived from the north-western corner of the province of British Columbia. Information obtained on the spot indicates that the value of the furs reaching Lynn Canal from the interior is from $12,000 to $15,000 annually. Routes of export of furs.

Economic Importance of the Region.

Without including the northern part of British Columbia, respecting which more has already been made known, but restricting ourselves to the great area of 192,000 square miles situated to the north of the 60th parallel and west of the Rocky Mountains, which I have referred to as the Yukon district, it may be said that the information now obtained is sufficient to warrant a confident belief in its great value. Very much yet remains to be learned respecting it, but it is known to be rich in furs, well supplied with timber, and it is traversed by a great length of navigable rivers. It is already yielding a considerable yearly product in gold, and presents every indication of a country rich as well in other metals, and including deposits of coal. In its southern portion, situated between the 60th and 65th degrees of latitude, is comprised an area of probably not less than 30,000 square miles, suitable for eventual agricultural occupation, and presenting none of the characters of a sub-Arctic region, which have, in advance of its exploration, been attributed to it by some writers. In each of these particulars and in climate it is greatly superior to the corresponding inland portion of the territory of Alaska. It may, in fact, be affirmed with little room for doubt, that the region here spoken of as the Yukon district surpasses in material resources the whole remaining northern interior portion of the continent between the same parallels of latitude. Value of the Yukon district.

The winter climate of the whole of this great region is known to be a severe one, and its northern extremity lies within the Arctic circle, but it must be remembered that the climatic conditions on the western and eastern sides of the continent are by no means comparable, and that the isothermal lines, representing the mean annual temperature, Isothermal lines.

trend not westward but north-westward from the Manitoba region. The lines, in particular, which would represent the mean summer temperature would assume, in the far north-west, a proximate parallelism with the Pacific coast, instead of tending to follow lines of latitude. It is needless here to recapitulate the well known causes which produce this remarkable difference in climate, but the lines as already approximately drawn upon the maps, represent in a generalized form the aggregate of influences which, working together, produce at the site of old Fort Selkirk on the 63rd parallel of latitude in the Upper Yukon basin, an attractive landscape, decked with well-grown forests and with intervening slopes of smiling meadow, while in the same latitude in Hudson Strait we find, even at midsummer, merely a barren waste of rocks and ice.

Comparison with province of Vologda.

To instance a region which reproduces the general conditions of the Yukon district and adjacent northern portions of British Columbia, we must turn to the inland provinces of Russia, to which allusion has already been made in connection with climatic features. (p. 23 B.) The province of Vologda, in European Russia, appears to offer the nearest parallel. It is circumstanced relatively to the western shores of Europe, as is this district to the western shores of the North American continent. Its area is 155,498 square miles, situated between the 58th and 65th degrees of latitude. The climate in both cases is a continental one, in which severe winters alternate with warm summers, and the actual degrees of cold and heat, so far as our information goes, are not disimilar. There is no very heavy rainfall in either region, such as we find near the western coasts bordering on the Atlantic and on the Pacific respectively. The agricultural products from the province of Vologda are oats, rye, barley, hemp, flax and pulse. The mineral products comprise salt, copper, iron and marble, but the precious metals do not appear to be important, as in the Yukon district. Horses and cattle are reared, and the skins of various wild animals, as well as pitch and turpentine, are among the exports. The population of the province is stated at 1,161,000.

Ultimate development assured.

While the Yukon district and the northern portion of British Columbia are at present far beyond the limits of ordinary settlement, we may be prepared at any time to hear of the discovery of important mineral deposits, which will afford the necessary impetus, and may result, in the course of a few years, in the introduction of a considerable population into even its most distant fastnesses. To-day it may well be characterized by the term which has been employed in connection with the Mackenzie basin, a portion of "Canada's Great Reserve." It appears meanwhile eminently desirable that we should encourage and facilitate, in so far as may be possible, the efforts of the miners

and others who constitute our true pioneers in the region, and to whom, in conjunction with the fur companies and traders, the peaceful conquest of the whole of our Great West has been due. In the future, there is every reason to look forward to the time when this country will support a large and hardy population, attached to the soil and making the utmost of its resources.

General Geology.

In a reconnaissance carried out along a single line, in which the greater part of one's time is necessarily occupied in overcoming the difficulties of the route and in securing the necessary geographical data, it is difficult to obtain any very complete knowledge of a region geologically complicated. In the present case this difficulty is increased by the circumstance that the geology of the corresponding portion of the Cordillera belt in the southern part of British Columbia, is as yet very imperfectly understood, though considerable attention has been devoted to it; while with respect to the older rocks of the analogous region in the western part of the United States very little published information of a systematic kind is available. Difficulties of the field.

Speaking broadly, however, and with reference to the general features of the region, the rock-series represented are evidently similar to those found in the southern portion of British Columbia between the Rocky Mountains and the coast, and an important general result of the work here reported on, is the further demonstration of the great constancy in lithological characters of the several formations, when followed in the direction of the main north-west and south-east axes of uplift—a constancy which contrasts markedly with the diversity found when comparisons are made as between localities situated at right angles to this direction. General similarity British Columbia.

The Coast Ranges, where traversed by the valley of the Stikine, and again where crossed still further north by the Chilkoot Pass, are found to consist, for the most part, of granite and granitoid rocks, almost invariably of gray colour and frequently rich in hornblende. With these are occasionally included stratified or stratiform masses of mica- and hornblende-schists, and both these and the granites are frequently traversed by pegmatite veins, diabase dykes and intrusive masses of coarse diorite. The schistose portions of these ranges may possibly represent the still recognisable remnants of rocks of Archæan age, or may be merely portions of much newer series which have suffered extreme alteration. Rocks of the Coast Ranges.

No demonstration of the date of the origin of the granitic rocks of the Coast Ranges was obtained in this region, but there is every reason

to believe that it is comparatively recent, and due to a time lying between the Triassic and the Cretaceous, as has been found to be the case with their continuation to the south, near the northern part of Vancouver Island.*

Rocks of the coast archipelago.

The argillites of Wrangell, together with those met with near Juneau, and at Sitka, on the Alaskan coast, and also in various places along the east side of Lynn Canal, together with the altered volcanic rocks found in association with these on Lynn Canal and elsewhere (examined by me particularly in the vicinity of Seduction Point), closely resemble rocks of the same class composing the Vancouver group of the Queen Charlotte and Vancouver Islands. Though no fossils were obtained at these northern localities, the rocks may, like those just referred to, be provisionally classed as Triassic, with the reservation, (as made in the case of the similar series of the Queen Charlotte and Vancouver Islands), that Palæozoic strata may also be represented.

General features of coast belt.

The width of the belt of granitoid rocks composing the Coast Ranges is, on the Stikine, about sixty-five miles, measured from their sea-border inland at right angles to the main direction of the mountains. It is somewhat less in the latitude of the Chilkoot Pass, but may be assumed to occupy a border of the mainland about fifty miles in width along the whole of this part of the coast. Broadly viewed, however, the coast archipelago in reality represents a partly submerged margin of the Coast Ranges, and granitic rocks are largely represented in it also. The examination of these two northern cross-sections of the Coast Ranges, serves, with observations previously made, to demonstrate the practical identity in geological character of this great orographic axis, from the vicinity of the Fraser River to the 60th parallel of north latitude—a length, in all, of about 900 miles.

Formations of the interior region.

East and north-east of the Coast Ranges, the interior region traversed is, for the most part, floored by Palæozoic rocks of very varied appearance, and probably referable to several of the main sub-divisions of the geological scale. In so far as the information obtained in the region here in question enables conclusions on the subject to be formed, the lowest part of the rocks, (1) consists of greenish and grey schists, generally felspathic or hornblendic, but often quartzose and including distinctly micaceous and talcose schists, with some bands of limestone; the lithological character of this sub-division being exceedingly varied. Apparently overlying these are, (2) grey and blackish, often lustrous and sometimes more or less micaceous calc-schists and quartzites, including beds of limestone of moderate thickness, which are often more or less dolomitic. These are associated with, or pass up into, (3) black

* See Annual Report Geol. Surv. Can., 1886.

argillites or argillite-schists, also containing thin beds of limestone, which, at one locality on the Dease, have afforded a small number of graptolites of Cambro-Silurian age (see p. 99 B). Next above these is a series (4) consisting chiefly of massive limestones, generally of grey or blue-grey colour where unaltered, but often locally changed into white or variegated crystalline marbles. These are closely associated with quartzites which usually show the peculiar fine grained cherty character of those of the typical Câche Creek series on the Fraser and Thompson rivers. The thickness of this sub-division cannot (any more than that of those previously mentioned) be stated with precision, but that of the limestones alone must be several thousand feet in some places. On the Dease, on the Frances, and again on Tagish Lake fossils of Carboniferous age, including more particularly a species of *Fusulina*, have been detected in some beds of this limestone series, probably belonging to its upper portion. Forms of the genus *Fusulina* are characteristic in certain zones of the Carboniferous limestone in California. They have been found by the writer in a number of places in British Columbia, which, with the discoveries here reported on, occur at intervals along a belt of country to the north-east of the Coast Ranges for a distance of over 800 miles. The limestone last-mentioned appears to be conformably followed or even in part interbedded with (5) a great mass of more or less evidently stratified rocks of volcanic origin, comprising amygdaloids, agglomerates, and other more massive materials which apparently represent old lava-flows. All these are highly altered, so much so that in some cases their original physical character is scarcely demonstrable, while they have suffered changes also in constitution, having been converted for the most part into diabases.

Fusuline limestones

Analogy with the southern portions of British Columbia which I have examined, leads me to believe that the greater part of these volcanic materials are also to be classed as of Carboniferous age, but it is quite probable that here, as to the south, they comprise as well rocks of similar appearance which are of Triassic age, but which we are at present unable to separate from them. This is further rendered probable by the occurrence in certain black argillites at Glenora, on the Stikine, of Triassic fossils (p. 56 B) and by the discovery by Mr. McConnell of fossils of this age on the Lower Liard River, some distance to the east of the region covered by this report.*

Altered volcanic materials.

No unconformity has been proved to occur throughout the whole of the above Palæozoic series, but the examinations made were scarcely of a sufficiently detailed nature for the detection of any stratigraphical break unless of a very obvious character. Respecting the first-mentioned of the above sub-divisions, I feel some doubt as to whether

Relations of the rock series.

* See Summary Report of the Operations of the Geological Survey for 1887, p. 11.

it really constitutes a lower member of the series or whether it may represent some of the other members—particularly the rocks of volcanic origin—in a highly altered state, as seems, from late observations, to be the case with rocks of similar appearance in southern British Columbia. The proximity of the rocks classed under the first sub-division to certain granitic axes is equally explicable on either hypothesis. It must also be added that there appears to be a recurrence of rock materials originally volcanic in greater or less force in several parts of the series, and that important beds of serpentine occur at one or more horizons.

Geological notes on map.

For the purpose of assisting future more complete enquiry, and in view of the tentative character of the classification here offered, the more important details observed are noted on the face of the map accompanying this report, for which it would be premature to attempt a geological colouring.

Interior granitic axes.

The preponderantly Palæozoic floor of the region east of the granites of the Coast Ranges, is broken through on two main lines by granitic axes. The first of these is cut across by the Dease River, a short distance below Dease Lake, and was again met with—over 300 miles north-westward—on the Pelly near the mouth of the Macmillan. Though referred to as a single granitic axis, this uplift probably consists rather of a series of alternating and more or less irregularly shaped granitic masses, which, however, preserve a general alignment. There are on the Upper Pelly in fact three separate granitic ridges in place of the single one met with on the Dease. In close association with these granites are some gneissic rocks and holocrystalline mica- and hornblende-schists, which have not been referred to in previous paragraphs as they are regarded as probably Archæan, rather than as representing highly altered Palæozoic rocks. A small tongue of granite occurs on the Lewes a few miles above the mouth of the Little Salmon, which may be connected with the south-western side of this granitic axis, but with this exception its continuity between the Dease and Pelly is indicated merely by the statement of Mr. J. McCormick that granites and mica-schists occur on the south-west side of Quiet Lake and near the Big Salmon River, below that lake. Its further extension in a north-westerly bearing is, however, proved by the occurrence of a great preponderance of rocks of the same character in the collection made by Mr. Ogilvie* on the lower Pelly or Yukon, between the mouth of the Lewes and Forty-mile Creek.

Connexion of gold with the rock series.

On comparing the position of this irregular granitic axis and its surrounding altered rocks (in part referable to several of the Palæozoic sub-divisions previously described) with that of the richer deposits of

* Sent out by him in charge of the latest party of miners in the autumn of 1887.

placer gold so far discovered and worked, it will be found that they are closely associated. The chief placers and river-bars are, in fact, scattered along this line or belt, and extend, like it, all the way from Dease Lake and McDame Creek to Forty-mile Creek. Evidence was moreover found on the Pelly, to show that the development of quartz veins in the Palæozoic rocks had occurred contemporaneously with the upheaval of the granites, and probably by some action superinduced by the granite masses themselves while still in a formative condition. While cutting the stratified rocks, the quartz-veins seldom or never cut the granite masses in this district. These observations should afford an important clue to the further search for auriferous ground, as well as for the lodes from which the placer gold has itself been derived.

Granites of Too-tsho Range.

Of the second granitic axis of the interior region very little is yet known, but it is probable that it is still less regular in character than the last. It occurs in the mountainous region to the east of Frances Lake and River, and probably also in the vicinity of the Pelly Lakes (see p. 121 B). Its lithological characters and those of the rocks in its neighborhood are similar to those of the last described, and here again in its vicinity, on Frances Lake and on the Liard (pp. 105 B, 113 B) paying gold placers have been found. The district is, however, so difficult of access that it can scarcely as yet be said to have been at all prospected.

Age of granites.

I am inclined to believe that the two granitic axes of the interior region above described are of much greater age than that of the Coast Ranges. The reasons for assigning a comparatively late date to the latter have already been alluded to. It is found, too, that while the stratified rocks usually conform to an ascending order in receding from these granitic axes, there is evidence along the north-eastern flanks of the Coast Ranges of an irregular line of junction, and though on the Stikine the Palæozoic rocks appear to rest upon the granites of the Coast Ranges, the supposed lower members of the series are not seen, while on the lakes near the head of the Lewes some of the upper portions of the Palæozoic are directly in contact with and have apparently been broken through by the granites. The granitoid rocks of the interior region are, moreover, different in general appearance from those of the Coast Ranges, and resemble more closely the probably Archaean granites of the Gold Ranges in southern British Columbia.

Lithological character.

Lithologically the granites and granitoid rocks of the Coast Ranges are generally fresh and unaltered in appearance, grey in colour and not often distinctly foliated, while those of the ranges of the interior show evidence of considerable alteration subsequent to their formation, are more highly quartzose and often reddish in tint. Some particulars respecting a few of the granites of the region which has been microscopically examined by Mr. F. D. Adams will be found in Appendix V.

Cretaceous and Laramie rocks.

Besides the Triassic rocks previously referred to, the Mesozoic period is represented also by strata of Cretaceous and Laramie age. These rocks are distinctively more recent in appearance than, and rest quite unconformably on all the older formations, though they have since been to some extent involved in their flexures. On the lower part of the Lewes, below the mouth of the Little Salmon, these rocks are cut across by the river for a distance of at least thirty-five miles. Some fossil molluscs and plants have been obtained from this area, from which it would appear to include beds referable to the Middle or Lower Cretaceous and to the Laramie period (p. 146 B), and it is not improbable that the series is a consecutive one between these limits, as the total thickness represented must be very great. The strike of these beds varies much in direction, and the angles of dip are so irregular that no even proximate estimate of thickness could be formed, and it is impossible to arrive at any definite conclusion with respect to the trend of the basin in which they lie. The rocks comprise, in their lower portion, coarse conglomerates, grauwacke-sandstones, yellowish and grey quartzose sandstones and dark calcareous slates. The upper portion, in which Laramie plants are found, consists chiefly of rather soft sandstones, shales and clays, generally of pale colours. Evidence of contemporaneous volcanic action is observable in both parts of the series, and the higher beds include lignite-coal of good quality (p. 148 B).

Some miles further up the Lewes, midway between the Little and Big Salmon rivers, peculiar green, grauwacke-sandstones and green, highly calcareous conglomerates occur, which are also provisionally referred, though with some doubt, to the Cretaceous. They are at least newer than the Palæozoic rocks, being composed of fragments of these and of the granites.

Cretaceous of Lake Labarge.

Conglomerates and sandstones similar to the last are again found near the lower end of Lake Labarge, on the east side, and are associated with black calcareous slates, which recur in several places along the same side of the lake, further up, and from which a few fossils have been obtained. These seem to show that the beds are on or near the horizon of Series C. of the Queen Charlotte Islands, which is of Middle Cretaceous age, approximately equivalent to the Gault (p. 158 B).

Cretaceous of Upper Pelly.

On the Upper Pelly River, forty-three miles below Hoole Cañon, a single low outcrop of hard, dark shales, containing fossil plants of Cretaceous or Laramie, age was found, but in the absence of further exposures along the river in that vicinity, nothing can be said of the extent of this area, except that it must be quite limited in width. Again, on the Stikine River, between Glenora and Telegraph Creek, there are local occurrences of conglomerates and soft sandstones which

may be regarded as probably Cretaceous, though no palæontological evidence is forthcoming.

The position of these last-noted areas, as well as that of those along the Lewes River, occurring as they do in a zone of country immediately within the line of the Coast Ranges, is analogous to that held by Cretaceous rocks on the Skeena and in other localities still further southward in British Columbia. Further investigation will probably show that rocks of this age occur in many additional places, and occupy somewhat extensive areas in this belt of country. In the vicinity of the Lewes, particularly, it is noted that the plane of the original base of the Cretaceous, now thrown into a number of folds, is about that of the present surface of the country, and these rocks may therefore be expected to recur frequently in the form of troughs or basins, more or less strictly limited and only to be discovered in detail by thorough examination. The loose material brought down by the Big Salmon River, appears to indicate the existence of a considerable development of these rocks not far up the valley of that stream. **Relations of the Cretaceous.**

No wide-spread Tertiary areas like those of the southern interior portion of British Columbia appear to occur in the region here described. The most important occurrence of beds of this age met with, is that which occupies the wide valley of the Upper Liard, but its extent to the north-west and south-east was not ascertained. The rocks are soft shales, sandstones and clays, generally of pale color, and holding beds of lignite in some places. Flows of basalt either cap these rocks or are included in their upper portion, and from the considerable angles of dip observed, the formation would appear to have suffered some flexure subsequent to its deposition (p. 101 B). **Tertiary rocks.**

In the Stikine valley, east of the Coast Ranges, important local basalt-flows are met with, overlying old river- and valley-gravels (p. 57 B), and the lignite reported to exist some miles up the Tahl-tan is, doubtless, also of Tertiary age and inferior in position to the basalts. Basalt effusions of a sporadic character may be frequent in other places in the region, as such were actually noted in three other widely separated localities, viz., above Hoole Cañon on the Pelly, at Miles Cañon on the Lewes, and again at the confluence of this river with the Pelly. **Basalts.**

The basalts are at least pre-glacial in age, and though no characteristic fossils were observed in the associated bedded deposits, both may be provisionally classed from their analogy with similar deposits in the more southern portion of British Columbia, as Miocene. **Age of basalts.**

Occurrence of Jade on the Lewes.

Occurrence of jade pebbles.

Having become interested in the question of the origin of nephrite or jade, on account of its former extensive employment by the natives of the west coast for the manufacture of implements, * I kept a close watch for this mineral along our route, and ultimately succeeded in finding several rolled pieces of it in gravel-bars along the Lewes (p. 147 B). Of the pebbles collected by us, at least five have the specific gravity and other physical characters of jade, though they have not yet been subjected to chemical or microscopical analysis. Several of these are evidently, however, pure and typical jade, of which the finest and most characteristic was found by Mr. W. Ogilvie, near Miles Cañon. This specimen is a pale-green translucent to sub-transparent variety weighing a pound and three-quarters, after a piece, probably equal to about one-fourth of the original mass, had been broken off and unfortunately lost. Some of the specimens collected, but not referred to in the above remarks, appear to show the passage, by admixture of other materials, of the pure jades into various altered rocks of volcanic origin, as described in the publication above referred to. So far as I have been able to ascertain, the discovery of jade here noted is, with one exception, the first actually direct one made in the region of the Pacific slope. The exception above alluded to is that of jade found at the Kwichpak mouth of the Yukon during Captain Jacobson's stay in that vicinity and which was obtained by him and taken to Berlin.†

Glaciation and Surface Deposits.

Such details as appear to be of interest respecting glaciation, and the superficial deposits, are given in the subsequent descriptive portion of this report. The general bearings of these are here merely summarized in the briefest possible manner.‡

Previous observations in British Columbia

Previous observations in British Columbia§ have shown that at one stage in the Glacial period—that of the maximum glaciation—a great confluent ice-mass has occupied the region which may be named the Interior Plateau, between the Coast Ranges and the Gold and Rocky Mountain ranges. From the 55th to the 49th parallel this great glacier has left traces of its general southward or south-eastward movement, which are distinct from those of subsequent local glaciers. The southern extensions or terminations of this confluent glacier, in

* See Canadian Record of Science, vol. ii. No. 6, April, 1887.

† See paper by Prof. A. B. Meyer, Jahresbericht des Vereins für Erdkunde zu Dresden, 1884.

‡ The substance of this summary has been published in advance in the Geological Magazine. Decade III, vol. v. p. 347 (Aug. 1888).

§ Quart. Journ. Geol. Soc. vol. xxxi. p. 89. *Ibid.* vol. xxxiv. p. 272. Canadian Naturalist, vol. viii.

Washington and Idaho Territories, have quite recently been examined by Mr. Bailley Willis and Prof. T. C. Chamberlin of the U. S. Geological Survey,* and their observations tend to confirm the views above outlined, which had previously been stated by the writer. There is, further, evidence to show that this inland-ice flowed also, by tranverse valleys and gaps, across the Coast Ranges, and that the fiords of the coast were thus deeply filled with glacier-ice, which, supplemented by that originating on the Coast Ranges themselves, buried the entire great valley which separates Vancouver Island from the mainland, and discharged seaward round both ends of the island. Further north, the glacier extending from the mainland coast touched the northern shores of the Queen Charlotte Islands. The observed facts on which these general statements are based have been fully detailed in the publications already referred to, and it is not here necessary to review former work in the region, further than to enumurate the main features developed by it, and to connect these with the observations made during the summer of 1887, in the more northern region described in the present report.

The littoral of the south-eastern part or "coast strip" of Alaska, presents features identical with those of the previously examined coast of British Columbia, at least as far north as lat. 59°, beyond which I have not seen it. The coast archipelago has evidently been involved in the border of a confluent glacier which spread from the mainland and was subject to minor variations in direction of flow dependent on surface irregularities, in the manner described in my report on the northern part of Vancouver Island. † No conclusive evidence was here found, however, in the valley of the Stikine River or in the pass leading inland from the head of Lynn Canal, to show that the inland-ice moved seaward across the Coast Ranges, though analogy with the coast to the south favours the belief that it may have done so. The front of the glacier must have passed the outer border of the archipelago, as at Stika, well-marked glaciation is found pointing toward the open Pacific ‡ (average direction about S. 81° W. astr.). Glaciation of the coast.

It is, however, in the interior region, explored and examined by us in 1887, between the Coast Ranges and the Rocky Mountains proper, and extending northward to lat. 63°, that the most interesting facts have come to light respecting the direction of movement of the Cordilleran glacier. Here, in the valleys of the Upper Pelly and Lewes, traces were found of the movement of heavy Glaciation of the interior region.

* Bulletin U. S. Geol. Survey, No. 40, 1887.

† Annual Report Geol. Surv. Canada, 1885, p. 100 B.

‡ Mr. G. F. Wright has already given similar general statements with regard to this part of the Coast of Alaska, American Naturalist, March, 1887.

glacier-ice in a northerly direction. Rock-surfaces thus glaciated were observed down the Pelly to the point at which it crosses the 136th meridian and on the Lewes as far north as lat. 61° 40′, the main direction in the first-named valley being north-west, in the second north-north-west. The points referred to are not, however, spoken of as limiting ones, for rock exposures suitable for the preservation of glaciation are rather infrequent on the lower portions of both rivers, and more extended examination may result in carrying evidence of the same kind further toward the less elevated plains of the Lower Yukon, as elsewhere detailed. Neither the Pelly valley nor that of the Lewes is hemmed in by high mountainous country except toward the sources, and while local variations in direction are met with, the glaciation is not susceptible of explanation by merely local agents, but implies the passage of a confluent or more or less connected glacier over the region.

On Lake Labarge, in the Lewes valley, both the sides and summits of rocky hills 300 feet above the water were found to be heavily glaciated, the direction on the summit being that of the main (north-north west) orographic valleys, while that at lower levels in the same vicinity followed more nearly the immediate valley of the river, which here turns locally to the east of north.

Glaciation was also noted in several places in the more mountainous country to the south of the Yukon basin, in the Dease and Liard valleys, but the direction of movement of the ice could not be determined satisfactorily, and the influence of local action is there less certainly eliminated.

Deposits of the glacial period.

While the greater part of the area traversed is more or less completely mantled with glacial deposits, it will be observed, in referring to subsequent pages, that true boulder-clay was found in certain parts only of the southern and more mountainous portion of the region, while it spreads over almost the entire length of the Upper Pelly and Lewes valleys, though not found exposed quite to their confluence. The boulder-clay generally passes upward into, and is covered by, important silty beds, analogous to the silts of the Nechacco basin, further south in British Columbia, and to those of the Peace River country to the east of the Rocky Mountains. It may be stated also that the country is generally terraced to a height of 4000 feet or more, while on an isolated mountain-top near the height of land between the Liard and the Pelly rivers (Pacific-Arctic watershed) rolled gravel of varied origin was found at a height of 4300 feet, a height exceeding that of the actual watershed by over 1000 feet.

Mastodon remains.

No remains of mastodon or mammoth were observed in the country traversed by us, but according to Campbell such remains occur not far

from the site of Fort Selkirk, and they are known to be moderately abundant at points further down the river. Sir J. Richardson speaks of a tibia of *Elephas primigenius* sent to England by Roderic (Robert) Campbell from this region.*

General facts established.

Reverting to the statements made as to the direction of the general glaciation, the examination of this northern region may now be considered to have established that the main gathering-ground or *névé* of what I have called the great Cordilleran glacier or confluent glacier-mass of the west coast, was included between the 55th and 59th parallels of latitude, a region which, so far as explored, has proved to be of an exceptionally mountainous character. It would further appear that this great glacier extended, between the Coast Ranges and the Rocky Mountains, south-eastward nearly to lat. 48°, and north-westward to lat. 63°, or beyond, while sending also smaller streams to the Pacific Coast.

Other instances of northward glaciation.

In connection with the northerly direction of ice-flow here ascertained, it is interesting to recall the observations which I have collected in a recently published report of the Geological Survey, relating to the northern portion of the continent east of the Mackenzie River.† It is there stated that for the Arctic coast of the Continent, and the Islands of the Archipelago off it, there is a considerable volume of evidence to show that the main direction of movement of erratics was *northward*. The most striking facts are those derived from Prof. S. Haughton's Appendix to M'Clintock's Voyage, where the occurrence is described of boulders and pebbles from North Somerset, at localities 100 and 135 miles north-eastward and north-westward from their supposed points of origin. Prof. Haughton also states that the east side of King-William's Land is strewn with boulders of gneiss like that of Montreal Island, to the southward, and points out the general northward ice-movement thus indicated, referring the carriage of the boulders to floating-ice of the glacial period.

The copper said to be picked up in large masses by the Eskimo, near Princess-Royal Island, in Prince-of-Wales Strait, as well as on Prince-of Wales Island,‡ has likewise, in all probability been derived from the copper-bearing rocks of the Coppermine River region to the south, as this metal can scarcely be supposed to occur in place in the region of horizontal limestone where it is found.

Dr. A. Armstrong, Surgeon and Naturalist to the *Investigator*, notes the occurrence of granite and other crystalline rocks not only on the south shore of Baring Land, but also on the hills at some distance

* Am. Journ. Sci. and Arts, vol. xix., 1855, p. 132.

† Notes to accompany a Geological Map of the Northern Portion of the Dominion of Canada East of the Rocky Mountains, p. 57 R., Annual Report Geol. Surv. Can., 1886.

‡ De Rance, in Nature, vol. xi. p. 492.

from the shore. These, from what is known of the region, must be supposed to have come from the continental land to the southward.

Dr. Bessels, again, remarks on the abundance of boulders on the shore of Smith's Sound in lat. 81° 30′, which are manifestly derived from known localities on the Greenland coast much further southward, and adds: "Drawing a conclusion from such observations, it becomes evident that the main line of the drift, indicating the direction of its motion, runs from south to north."*

It may further be mentioned that Dr. R. Bell, has found evidence of a northward or north-eastward movement of glacier ice in the northern part of Hudson Bay, with distinct indications of eastward glaciation in Hudson Strait. † For the northern part of the great Mackenzie valley we are as yet without any definite published information, but Sir J. Richardson notes that Laurentian boulders are scattered westward over the nearly horizontal limestones of the district.

Two great glacier-masses.

Taken in conjunction with the facts for the more northern portion of the continent, already pretty well known, the observations here outlined would appear to indicate a general movement of ice outward, in all directions, from the great Laurentian axis or plateau which extends from Labrador round the southern extremity of Hudson Bay to the Arctic Sea; while a second, smaller, though still very important region of dispersion—the Cordilleran glacier-mass—occupied the Rocky Mountain region on the west, with the northern and southern limits above approximately given, and a length, in a north-west and south-east direction, of at least 1200 miles.

It is inexpedient at the present moment to enter into any detailed discussion of the glaciation of the extreme north-west, as Mr. McConnell's observations, made in the prosecution of his portion of the work of the expedition, are likely to add much to our store of facts bearing on the subject.

Economic importance of facts elicited

It may be added, that while the study of the phenomena of the glacial period is one not without its bearings on economic problems even in the eastern part of the continent, it has, in British Columbia and the Yukon district, a direct value in its connection with the distribution of the placer gold deposits and on the existence and position of the buried channels of rivers and streams, in which some of the richest of those deposits are often found to occur. Thus the greater part of the "fine" gold found along the river-bars and banks of the larger streams in the Yukon district is doubtless proximately derived from the gravels

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* Nature, vol. ix.

† Annual Report Geol. Surv. Canada, 1885, p. 14 D.D. and Report of Progress, 1882-84, p. 36 D.D.

and other superficial deposits in which these streams have re-excavated their beds since the period of glaciation. By the general dispersion and intermixture of these materials, composed of the *débris* of the older rock formations, it is even possible that the existence of a few comparatively limited areas of great richness might account for the wide-spread auriferous character of the alluviums of the Upper Yukon basin. In the former direction of ice-movement, and consequently that of its transport of material, we obtain an important clue as to the source of the finer gold which may now be found in any particular area. This subject is too wide in its ramifications to be followed out here, but it is one to which considerable attention has been devoted, and to which I hope to return at an early date in greater detail.

Volcanic Ash Deposit.

Extent of the deposit.

A circumstance of some interest in connection with the later superficial deposits of that part of the Upper Yukon basin drained by the Lewes and Pelly rivers, is the occurrence of a wide-spread layer of volcanic ash or pumiceous sand. The existence of a peculiar white line or band in the upper parts of scarped banks along the river, was first remarked not many miles below the point at which we reached and embarked on the Pelly. As its character was not at first understood, I omitted to note the precise point at which it was first seen but am of opinion that it probably extends to the east of the place where we reached the river. After recognizing its character and importance, however, it was looked for and noticed almost continuously along the whole course of the Pelly, as far down as the mouth of the Macmillan, beyond which, to the site of Fort Selkirk at the mouth of the Lewes, it was not distinctly recognized, but according to Mr. McConnell (1888) it extends down the river for about ten miles below Fort Selkirk. It is likewise seen along nearly the whole course of the Lewes, being last noted at the narrows between Lake Nares and Bennett Lake, known as Caribou Crossing. *

Origin of the deposit.

This ash deposit appears to be entirely due to a single period of eruption. It is homogeneous in character wherever seen, forming a single layer not divided by intercalations of other material, and has been spread everywhere over the entire area characterized by it. It is much more recent in date than the white silt deposits, which are the last of those properly referable to the glacial series, having been deposited after the river-valleys were excavated in the glacial materials, and at a time when the rivers had cut down nearly or quite to their

* I found subsequently that Schwatka had observed this peculiar layer along the Lewes and *correctly* characterized it as a volcanic ash. Along Alaska's Great River, p. 196.

present levels, a fact rendered evident by the circumstance that it overlies the deposits of river- and valley-gravels and sands in all cases, except in those of some low river-flats, where these deposits sometimes cover it to a depth of several feet. In most places it is overlain merely by the surface soil with a depth of six inches to two feet, and in a few instances it was noted as constituting the actual surface of terraces of moderate height, the present forest being rooted in it.

Mode of deposition and thickness. The ash appears to have fallen tranquilly, much in the manner of snow deposited from a calm atmosphere. The examination of scarped banks along the two rivers showed it to occur near the surface of terraces about 200 feet in height, as well as on lower terraces and river-flats down to within about ten feet of the actual river-level in August and September. It was also detected in some places on the sloping fronts of terraces. The thickness of the layer was no doubt originally pretty uniform, and it still retains this uniformity where it rests upon wide flat terraces. Its average normal thickness for the Pelly, as a whole, was estimated at about five inches, but this is somewhat exceeded along the part of the river immediately above the Macmillan. On the Lewes, below Rink Rapid, its normal thickness is about a foot, but above this point it becomes much less and where last seen, at Caribou Crossing, is not over half an inch thick, and only to be recognized when carefully looked for.

Local accumulation. In addition to these differences in normal thickness, however, and much more striking than them, is an irregularity due to local circumstances. Thus in hollows, and particularly when these occur at the foot of steep slopes, the material has evidently been washed together by rains occurring shortly after its deposit, and sometimes attains a thickness of as much as three feet. In correspondence with this it has been completely removed from some sloping or exposed surfaces. The same local circumstances explain the varying depth in different localities of the soil or ordinary sand which overlies the ash deposit.

Where the ash deposit rests undisturbed upon the original surface, this appears very generally to be a yellowish or reddish quartzose sand. There are, in some cases, remains of burnt trees at the base of the layer, and traces of similar forest fires are found as well in the sand or soil overlying it.

Source of the ash deposit. So far as the observations I was able to make go, the volcanic ash is thicker on the lower part of the Lewes than elsewhere, and the thickest part of the deposit on the Pelly lies nearly due east of the portion of the Lewes just referred to. The greater mass of the deposit in that direction, seems to show that it was derived from the westward, and a line drawn across the portions of the Pelly and Lewes above defined, lies between the 62nd and 63rd parallels of latitude, with a nearly east-and-

west bearing, so that if produced to the westward it would pass, at a distance of about 200 miles, through the mountain region near the Copper River, of Alaska, which includes Mount Wrangell. Mount Wrangell is the nearest known volcano,* and this or one of the

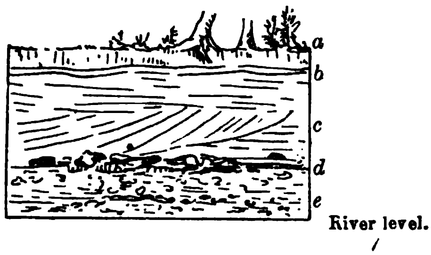

FIG. 1. RELATIONS OF ASH-BED ON THE LEWES RIVER.

a. Soil. *b.* Ash-bed. *c.* Stratified sands and gravels. *d.* Buried drift-wood. *e.* Stratified gravels.

neighbouring mountains in the same group, may not improbably have been the source of the material which has been so widely spread over the Upper Yukon basin. It should be stated, however, that the Indians report the existence of a burning mountain near the head-waters of the White River, and that it is uncertain whether this report refers to Mount Wrangell or to some still unknown mountain which may be even nearer to the district here described.

Date of the eruption.

Respecting the date of the eruption to which the ash-bed is due, very little can be said with certainty. As already noted, the rivers have not certainly cut their beds perceptibly deeper since the deposit occurred on their flood-flats, so that the period to which it belongs cannot be an exceedingly remote one. It was further observed in one place, on the Lewes, to rest upon stratified sands a few feet thick, which in turn overlie a mass of drift logs still quite sound and undecayed. This fact, with the general appearance and mode of occurrence of the deposit, leads me to believe, that while the eruption must have happened at least several hundreds of years ago, it can scarcely be supposed to have taken place more than a thousand years before the present time. Dall, in his work on Alaska, gives a list of volcanic eruptions (derived from Grenwingk) which have occurred in the Aleutian Islands and along the western part of the Alaskan Coast from the year 1690. † While it is quite improbable that any of these was connected with the formation here described, it is interesting to note that great quantities

* See Lieut. H. T. Allen's Reconnaissance in Alaska, Washington, Government, 1887.

† Alaska and its Resources, 1870, p. 466.

of ash were observed to fall on several occasions, notably in 1825, when the whole peninsula of Alaska was covered with black ashes.

Volume of ash ejected.

That the eruption of which the occurrence is marked by the ash-bed of the Lewes and Pelly, was on a great scale, is sufficiently evident from the extent of the deposit; which must necessarily be very much greater than the area to which the present observations refer. By drawing a line such as to include the outer limits of the observed extent of the ash, a roughly triangular area of about 25,000 square miles is outlined, and if we assume the average depth of the layer over this area alone to be three inches, the mass represented would be equivalent to a prism one mile square, with a height of 6240 feet or (making allowance for interspaces in the comminuted material) equal to nearly a cubic mile of rock.

Lithological character.

It has not been considered necessary to make a complete examination of the character of this ash. In appearance it is a fine, white, sandy material, with a harsh feeling when rubbed between the fingers Microscopically it is found to consist chiefly of volcanic glass, part being merely frothy and pumiceous, but of which the greater portion has been drawn out into elongated shreds, frequently resembling the substance known as "Pele's hair," in which the enclosed vesicles become more or less completely tubular. In addition to this glass, fragments and small perfect examples of sanadine felspar crystals occur together with portions of minute crystals of hornblende and probably of other minerals.

The Stikine River.

General Features.

River cuts across the Coast Ranges.

Since the year 1873, when the placer gold mines of Cassiar were first developed, the Stikine River has become a somewhat important avenue of communication from the coast to the interior of the northern part of British Columbia. Like the Fraser, the Skeena, the Nass and several other smaller streams, it rises to the east of the broad belt of mountains which constitutes the Coast Ranges, and cuts completely through this belt with a nearly uniform gradient. In size and general character the Stikine closely resembles the Skeena, which reaches the coast 200 miles further south. It is navigable for stern-wheel steamers of light draft and good power, to Glenora, 126 miles from Rothsay Point, at its mouth, and under favourable circumstances to Telegraph Creek, twelve miles farther. Above Telegraph Creek is the "Great Cañon" which extend for many miles and is quite impassable either for steamers or boats, though traversed by miners in winter on the ice. The head-waters of the Stikine are unknown, but lie for the

Route to the interior.

most part to the south of the 58th parallel of north latitude, in a country said to be very mountainous, interlocking there with northern branches of the Nass and western feeders of the Black or Turnagain River, a tributary of the Liard. From Telegraph Creek, the head of navigation, a pack-trail sixty-two miles and a-half in length, constructed by the British Columbian Government, follows the valley of the Stikine, generally at no great distance from the river, and eventually crosses from the Tanzilla or Third North Fork to the head of Dease Lake, which may be regarded as the centre of the Cassiar mining district. This route has long been known to the Indians, the Stikine having been to them from time immemorial an important avenue of trade, by which, as by the Skeena, the coast tribes penetrated a considerable distance inland.

My personal acquaintance with the Stikine, as far as Telegraph Creek, was such only as could be made from the deck of the little steamer in which we ascended the river to that point, and merely enabled me to note the main features of the valley. This was supplemented, however, by the observations of Mr. McConnell, who remained behind for the purpose of making a micrometer survey of the river from the furthest point reached by Mr. Hunter's survey of 1877 to Telegraph Creek. Mr. McConnell's notes and map with specimens collected by him have been consulted in the following sketch of the river, and are drawn upon particularly in respect to its geological features. Information obtained.

As the result of Mr. McConnell's survey, taken in conjunction with that of Mr. Hunter, we are now for the first time in possession of a correct map of the river to the head of navigation. The best general map of the river and route to Dease Lake previously in existence, was a sketch made by Mr. G. B. Wright and published in the report of the Minister of Mines of British Columbia in 1875. This map also includes Dease Lake and part of the Dease River, and I may take this opportunity of stating that much credit is due to Mr. Wright for its general accuracy, taking into consideration the circumstances under which it was made. Map of the river.

The general trend of the Stikine valley for twenty miles from the sea, is east-and-west, corresponding in direction to Bradfield Canal, which penetrates the coast thirty miles to the south, and also to part of the northern portion of Behm Canal and Burroughs' Bay, still further south. At this distance from the coast the river bends through a quadrant of arc, and assumes a nearly due north direction, which it maintains for about sixty-six miles, beyond which the valley is continued in a nearly direct north-eastward course to the vicinity of Dease Lake, but in its upper portion is occupied, not by the main river, but by the Tanzilla or Third North Fork, the main river entering this continuous valley from the southward. Trend of the main valley.

The Coast Mountains.

The particular range of the Coast Mountains, which locally assumes a culminating or axial character on the Stikine, is that which is traversed by the river-valley near the great bend above alluded to. As seen from the sea, at some distance off shore, it is notably higher and rougher to the north of the river-valley than to the south of it, and is surmounted by sharp, jagged, rocky pinnacles in some places. The highest summits in this range here probably average about 8000 feet. It carries much snow throughout the year, and in it are the sources of the principal glaciers which debouch along the north-and-south part of the river above the great bend. The inland border of the Coast Mountains may be said, on the Stikine, to be near Glenora, giving a transverse width, from the coast, for this rugged belt of country of nearly eighty miles.

Current of the river.

The current of the navigable portion of the Stikine is swift throughout, but there are no rapids properly so called, though the Little Cañon (fifty-three miles above the great bend) forms a serious impediment to navigation when the river is at its highest stage in June or July, in consequence of the great velocity of the current in this narrow and rocky though deep gorge. Near the mouth of the river the current scarcely surpasses two miles an hour, but it increases as the river is ascended, till it attains a rate of six to seven miles in many places between the great bend and Telegraph Creek, the swifter water being chiefly met with above the Little Cañon. The average rate of flow of the navigable portion of the river must be about five miles an hour. The width of the Stikine immediately opposite Telegraph Creek was found on May 29th to be 480 feet only, but it is here deep, and had a velocity of 6·08 miles per hour, as determined from several observations. A few days later it was rising fast, and the velocity was considerably greater.

Navigation.

Stern-wheel steamers for the navigation of the river should have good engine power, and should draw not more than four feet of water when loaded.

The height of the river above sea-level at Telegraph Creek, as deduced from simultaneous barometric observations at the mouth and at this place, is 540 feet, giving an average fall of over four feet to the mile by the course of the stream. The actual fall on the upper part of this length of the river must, however, considerably exceed this figure, while that of the lower portion is inconsiderable. Under ordinary circumstances the ascent of the river to Telegraph Creek, with a suitable steamer, occupies about three days, and it is generally necessary to carry a line ashore at a few places. The extensive flats near the mouth of the river render it necessary to enter it about high-tide. Mr. Hunter ascertained that the channel across these

flats has from one to two feet only of water at low tide. A considerable proportion of the traffic is carried on by Indians with canoes, and the Stikine Indians are very expert in all the necessary operations of tracking and poling in swift water.

Notes on the dates of opening and closing of the river will be found on page 60 B.

Lower part of river at one time an inlet.

The entrance to the Stikine from the sea is not distinguishable in its main orographic features from that of many of the salt-water inlets by which this part of the West Coast is dissected. The lower portion of this river-valley may, in fact, be regarded, like that of the corresponding part of the Skeena, as an inlet which has become filled with detritus in consequence of the great size and sediment-carrying capacity of the river which has emptied into it. Unlike the Skeena, however, the *débris* brought down has in this case been projected seaward so as to completely block the wide channel between the mainland coast and Mitkoff Island with shallow tide-flats and bars, above which several smaller, high, rocky islands project. The mountains immediately bordering the valley of the Stikine at its seaward entrance are from 2000 to 3000 feet in height, and rise abruptly from the wide alluvial flats, through which the river there winds, often without even touching the lower spurs of the hills.

Character of valley to Little Cañon.

The flats are generally covered with fine groves of cottonwood, mingled with spruce and other trees, and are often cut through by sloughs and channels, which become so numerous in some places as to render it difficult to decide which is entitled to rank as the main stream. The valley-bottom maintains an average width of from two to three miles as far up as the Little Cañon, which place may be regarded as nearly marking the head of the old salt-water inlet which has been silted up by the river. The cañon is about three-fifths of a mile long, and in places not more than fifty yards wide. It is bordered by massive granite cliffs, 200 to 300 feet in height, above which, on the west side, rugged mountain slopes rise. On the east, are low rocky hills representing part of a former spur of the mountain, through which the cañon has been cut. A tract of low land separates these hills from the eastern side of the main valley, and it is difficult to explain under what circumstances the river has taken its present course.

Valley above Little Cañon.

For some distance above the Little Cañon the Stickine valley appears to cut very obliquely through a series of somewhat irregularly parallel ranges. Eight miles further up is the "Kloochman Cañon," which to some extent repeats the features of the last, but it is nearly 300 feet in width and offers no impediment to navigation. At four miles above the "Kloochman Cañon" is the so-called "Grand Rapid," which, in consequence of recent changes in the river, is now by no means formid-

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able, though the water is still particularly swift and the river wide and shallow. Here the valley begins very markedly to open out, the mountains retiring further from the river and decreasing in altitude, while irregular, basaltic hills, of no great height appear between the river and the bases of the mountains. This, taken in conjunction with the dry climate which characterizes the country to the east of the mountains, and the fact that most of the slopes have been bared of timber by fire, gives an entirely different aspect to the landscape.

Iskoot River.

The Stikine is joined by some important tributaries in the part of its course above described, though none of these have yet been examined in detail. The Iskoot or Skoot, which flows in from the eastward about thirty-five miles from the mouth, or just within the locally culminating range of the Coast Mountains, is known to be navigable for some distance by canoes, and one branch is said to head not far from the extremity of Portland Canal, to the southward. By following this river to its head and there making a portage, the Indians are reported to be able to reach the Nass River without difficulty. The Iskoot has been prospected by a few miners, but apparently without any notable result, though the Indians report the occurrence of coal. The northern branch of the Iskoot, to the east of the Coast Mountains, was traversed in 1867 by P. J. Leech, of the Western Union Telegraph Exploration Survey, who crossed from it to the head of the First South Fork of the Stikine. The valley is there reported to be from 2500 to 3700 feet above sea-level, generally timbered, but with some open, grassy slopes.

Scud River.

About seven miles below the Little Cañon, the valley of the Scud River opens to the east, but the exact position of the mouth of the stream has not been fixed on the map. Some gold has been found by prospectors on this stream, but no workable placer deposits. It is said to head in a low country behind the Coast Mountains, and if this be correct, must nearly inosculate with branches of the Iskoot and First South Fork of the Stikine.

Clearwater River.

Six miles above "Kloochman Cañon," the Clearwater River enters the Stikine on the west side, by several mouths. This is a stream of considerable size, and is navigable for canoes for some distance. It is said to head near the sources of one branch of the Taku River, and is noted by the Indians on account of the great number of salmon which ascend it.

First South Fork.

The First South Fork joins the Stikine about a mile and a-half below Telegraph Creek. It is a large turbid stream, and for a number of miles from the main river, flows in a rough narrow gorge, between high hills and mountains. Further up, according to the Telegraph Exploration sketch, it is bordered by level, partly timbered terraces or

"benches." The summit between its head-waters and those of the Iskoot, on the route followed by Mr. Leech, is given on his authority at 5000 feet. Salmon do not ascend this stream.

Telegraph Creek is an inconsiderable stream, which falls rapidly to the river through a narrow rocky cleft in the bordering hills of the right or north-west bank of the Stikine. Its name is due to the fact that here the Western Union Telegraph line was intended to cross the Stikine. The little town of Telegraph Creek occupies the narrow delta of the stream and the lower terraces bordering it on both sides, its site being identical with that of "Fort Mumford" of the older maps. Glenora, twelve miles below Telegraph Creek and on the same side of the Stikine, consists of a single row of houses built along the edge of the river at the foot of a steep bank. Both places were at one time busy little towns, but are at present very much reduced in importance, though I believe it will probably not be long before further mining developments in the Cassiar district will lead to the renewal of their activity. **Telegraph Creek and Glenora.**

Glaciers.

The glaciers constitute one of the most remarkable features of this part of the Stikine valley. There are a number of these on both sides of the river, in its lower part; but four only of special importance, all of which are situated to the west of the river, and all but the first on the eastern slopes of the most massive central ranges of the mountainous region. The only detailed previous notice of these glaciers is that given in a report by W. P. Blake.* Mr. Blake's account of the glaciers is transcribed in the Fifth Annual Report of the United States Geological Survey, where it is placed under the somewhat misleading title of Glaciers of "Alaska." Two of the glaciers are illustrated in the last-mentioned volume by reproductions of photographs taken under the direction of Dr. J. W. Powell, Superintendent of Indian Affairs in British Columbia. That named the "Orlebar Glacier" represents part of the front of the Great Glacier of the miners and of Mr. Blake's map. The "Bernard Glacier" I am unable to identify with any certainty, but the illustrations evidently represents part of either the Flood or Dirt Glacier. **Previous notes on the glaciers.**

Mr. John Muir, who spent some time on the Stikine in 1879, gives an interesting popular description of its glaciers in a letter dated from Sitka in December of that year, and published in the San Francisco Bulletin. Mr. Muir informs me that no more systematic account of his observations in this region has yet been made public. The glaciers

*Geographical notes upon Russian America and the Stikeen River. W. P. Blake, Washington, Government. 1868.

are also noticed at some length in an account of a trip on the Stikine by Mr. W. H. Bell in Scribner's Monthly, 1879, Vol. XVII. The accompanying illustrations, though striking and artistic, have been idealized so far as to be scarcely recognizable.

Little Glacier.

The glacier known as the First or Little Glacier by the miners (named the Popoff Glacier by Blake) fills a high valley on the north side of the river, about ten miles from its mouth. As seen from a distance it offers no features of particular interest, resembling many other minor glaciers of the Coast Mountains.

Great Glacier.

The next and most important glacier, is that universally known on the river as the Great Glacier, and so named also by Mr. Blake, who gives an excellent description of its main features. The high snow-fields from which this glacier must take its rise are not seen from the river, the glacier entering the wide valley of the Stikine nearly at right-angles, through a break in the mountains two to three miles distant from the river bank. Before entering the Stikine valley, the glacier has a width estimated at from one-half to three-quarters of a mile, but upon freeing itself from the bordering mountains immediately expands in a fan-like manner, its actual front upon the river being from three to three and a-half miles in width. The slope of the surface of the glacier where it issues from the mountains was estimated — as seen at right angles — at above five degrees. Beyond this point it flattens out, and portions of the surface become extremely rugged, breaking off near the front in series of descending steps, as described by Mr. Blake. When seen by us, on the 20th of May, much of the surface was still covered by the new snow of the preceding winter, but notwithstanding this, a great quantity of rocky *débris* was visible, giving a grey tint to portions of the ice. The front of the glacier appears to be quite close to the edge of the river, but is actually about a third of a mile distant at the nearest points. This interval is occupied by moraines and marshy pools, the outer tier of moraines, or that nearest to the river, forming wooded hills about one hundred and fifty feet high. The newer moraines were partly covered and overridden by the front of the decaying ice. Large streams issue from beneath the ice, the position of outflow frequently changing from year to year.

Next to its size, the most remarkable feature about this glacier is the regularity of the fan-like form in which it terminates. It resembles in this respect the Davidson Glacier on Lynn Canal.

Recession of the glacier.

The miners state, that during the few years which they have known the Stikine the Great Glacier has steadily and notably receded, though the total amount of such recession can evidently not have been more than the distance from the wooded bordering-moraine to the present

ice-front. The Indians relate as a tradition, that at a former period the glacier stretched completely across the valley, the Stikine passing beneath the ice through a tunnel-like opening. It is, however, impossible to determine whether this is a remembered fact or a fancied inference. Curiously enough, a copious hot spring is situated immediately opposite the glacier on the east side of the Stikine valley.

Ten miles above the Great Glacier, and also on the west side of the valley, is the Dirt Glacier, so named by the miners because of the great quantity of rocky *débris* with which its surface is covered.* This is much smaller than the last, having a width estimated at a quarter of a mile, but possibly greater than this. Like the Great Glacier, it comes quite down on the river-flats. Dirt Glacier.

The last important glacier, sixteen miles still further up the river, is the Flood Glacier. This also comes down to the level of the river-flats, but does not closely approach the river. From the valley of this glacier a great rush of water occurs almost every year towards the end of the summer. This, no doubt, arises from the blocking by the glacier of the mouth of some lateral valley in which a lake is formed and from time to time breaks through the glacier dam. The quantity of water thus liberated is so great as to raise the river from a low stage to half-flood level for a short time. There is a large quantity of *débris* also on this glacier, though less than on the last. Flood Glacier.

Geological Notes on the Stikine.

The only information as to the geology of the Stikine, up to the present time, has been that embodied in notes in Mr. Blake's report, already referred to,† and these include the lower portion of the river alone, as his furthest point was a few miles above the Little Cañon. The results of Mr. Blake's examination are by himself summed up in the following terms:—"The mountains of the Stikine valley, from the Little Cañon down to near the coast, are formed of syenite and granite, with some metamorphic beds at intervals. The walls of the Little Cañon are granite. At the mouth of the river, and below the Indian villages, the rocks are quite different, being formed of the great sandstone and shale formation already described. The direction of uplift of these strata is about N. 80° W. magnetic. This formation is some thousands of feet thick, and resembles the rocks of San Francisco, but is more changed by metamorphic action. They are probably of the secondary period. It appears to pass into mica- Mr. Blake's observations.

* Also so named on sketch map in Report on Customs District, Public Service and Resources of Alaska Territory, by W. G. Morris, 1879.

† Mr. Blake's notes on the geology of the river are also given in Petermanns Mitteilungen, vol. x, 1861.

slate just above the site of an old stockade or fort of the Hudson Bay Company, where I found a locality of garnets like those of Monroe, in Connecticut."*

Rocks of Wrangell Island.

The rocks seen along the west shore of Wrangell Island, in the vicinity of the town and harbor, are chiefly black, flaggy argillites, remarkably uniform and regular in their bedding and with a westward dip. They are considerably indurated and contain small staurolite crystals in some layers, while on the surface of others crystals of mica have been developed. Similar rocks are found on other parts of the coast, both to the north and south, and from a lithological point of view, they much resemble the Triassic argillites of the Queen Charlotte Islands, though no fossils were found at this place. The ridge behind the town of Wrangell is chiefly composed of rather fine-grained grey granite, which is probably intrusive and may have been the cause of the incipient crystallization observed in the argillites. The north point of the island is formed of similar granite, probably a continuation of the same mass.

Rocks at month of river.

On crossing to the mainland, to the eastward, mica-schists and granites are met with, and beyond Rothsay Point (which may be regarded as the entrance to the Stikine River) granitic rocks only were seen for some miles. Near Rothsay Point, at a short distance from the shore, is the locality from which are obtained fine claret-colored garnet crystals, sometimes an inch or more in diameter. The matrix of these, as seen in hand specimens, is a dark, highly crystalline mica-schist, but the locality was not visited. The general strike of the rocks west of Rothsay Point is about S. 35° E., with prevailing westward dips.

Garnets.

Rothsay Point to Great Glacier.

From Rothsay Point to the Great Glacier, the mountains bordering the river are chiefly composed of granites and granitoid rocks. These alternate with gneissic and schistose rocks of similar composition, including mica-schists; but massive granites probably form much the greater part of the whole. The granites are usually grey in colour, and contain both hornblende and mica, with white felspars, which are often porphyritic, giving the rock a spotted appearance.† Some varieties become granitoid diorite, while others are highly quartzose, and contain little or no hornblende. The series as a whole closely resembles that cut across by the Fraser River in its lower course, and generally characteristic of the Coast Ranges of British Columbia.‡

Rocks brought down by the glacier.

The Great Glacier, rising many miles back in the higher ranges of the mountains, in the material which it has brought down and deposited in its moraine, affords a mode of ascertaining the gen-

* This does not appear to be the locality near Rothsay Point, subsequently mentioned.

† See note on the lithological character of the granites, Appendix V.

‡ Compare Annual Report Geol. Surv. Can., 1886, p. 11 B.

eral composition of the central ranges. This material was found by Mr. McConnell to consist almost entirely of grey granite of medium grain, composed of felspar, quartz and hornblende in nearly equal proportions, but holding also a little mica and occasional crystals of sphene. Diorites and mica-schists occur in smaller quantity, together with coarse pegmatite, which is evidently derived from veins intersecting the granite.

Kloochman Cañon to Grand Rapid.

Similar granitoid rocks, with occasional schistose areas, constitute the whole of the rock-exposures seen along the river to the so-called Grand Rapid, about four miles above "Kloochman Cañon". The mountains bordering the valley also appear to be entirely, or almost entirely, composed of the same materials, though at one place, (nearly opposite the site of the Hudson Bay Company's old post) the upper portion of a mountain seems to show a massive bedding, recalling that of the Cretaceous quartzites of Tatlayoco Lake, which occur there in a similar position relatively to the Coast Ranges.* No further evidence was, however, met with tending to show that rocks of this age occur here.

Stratified rocks at Grand Rapid

A short distance below the "Grand Rapid," distinctly stratified rocks of dark colour are seen capping some of the mountains and resting upon the granites. These beds have a dip of N. 70° E. < 30°, which brings them down to the level of the river near the rapid. They are there found to consist of hard argillites and grauwacke-quartzites, interbedded with shaly, grey and brownish impure limestones, the whole being considerably disturbed and cut near the granites by coarse grey porphyritic dykes of that rock. The argillites were not observed to hold staurolite, mica, or other crystalline minerals like those of Wrangell, and otherwise differ somewhat in appearance from these, though their relation to the granitic rocks appears to be similar. They are followed in ascending order by a massive grey-blue subcrystalline limestone of considerable though undetermined thickness, which can be traced in the mountains for some distance on both sides of the valley. These limestones are believed to represent those afterwards noted on the Dease and there referred to the Carboniferous period.

Altered volcanic rocks.

About two miles and a-half above "Grand Rapid," near the mouth of the Clearwater, the limestone is followed—apparently still in ascending order—by a series of altered volcanic rocks which are, for the most part of grey and greenish colours. These are apparently chiefly diabases, but include also porphyrite-like rocks. The rocks are generally rather fine grained, and would require microscopic examination before they can be named in detail.† Though clearly forming a

* Report of Progress, Geol. Surv. Can., 1875-76, p. 253.

† One of these which has been microscopically examined by Mr. F. D. Adams is described in Appendix V. as a diabase-porphyrite (Stikine No. 16.)

stratified series, evidence of bedding can seldom be detected in the exposures, in consequence of their homogeneous composition and shattered state. They seem to be identical with those forming a part of the Câche Creek group, in the southern interior of British Columbia, and though no fossils were found in the limestones previously mentioned, they, and possibly also the argillites beneath them as well, may be referred with considerable probability to the same Upper Palæozoic age.

Argillites and limestones.

Altered volcanic rocks only, like those above noted, were seen along the river for about twelve miles above the Clearwater, but there is reason to believe that outliers of Tertiary basalt also occur in this part of the valley. At the distance just mentioned above the Clearwater, and about six miles and a-half below Glenora, exposures are found of slaty argillites and dark shaly rocks, containing some impure limestone, all very much broken and disturbed, and associated with altered volcanic materials. Some beds of these shaly limestones prove on microscopical examination to consist chiefly of organic fragments which are not, however, sufficiently distinctive for the reference of the beds.

Triassic fossils.

Dark shaly rocks occur near Glenora which were not specially examiued. It is probably from these that some specimens containing Triassic fossils, which were given to me some years age by Mr. J. W. McKay, were derived. The form represented is a species of *Holobia*, probably a finely sculptured variety of *H. Lommeli*.

Tertiary volcanic rocks.

From this point to Telegraph Creek, basaltic and other comparatively modern volcanic rocks become prominent features, the basalts appearing as remnants of horizontal flows, the broken edges of which form scarped cliffs. These rocks are due to a period antecedent to that of the glacial deposits, and are of Tertiary age. Analogy with neighboring parts of British Columbia indicates that they may be assigned with probability to the Miocene. The basalts have evidently flowed along and partially filled the old river-valley, and unconformably overlie the old altered volcanic rocks previously alluded to, as well as all the other rock series.

About two miles below Glenora, the basaltic rocks were noticed in one place to have filled the old river-bed, conforming in their lower layers to the slopes of its sides, and to have been subsequently cut across obliquely by the present river. Other examples of this character are mentioned on following pages and are of special interest in connection with the occurrence of placer deposits of gold.

Palæozoic and Cretaceous rocks.

Between Glenora and Telegraph Creek, the rocks seen below the basalts include at least two distinct series. The first and oldest of these is represented by a number of occurrences of altered volcanic rocks, like those previously referred to, as well as by considerable exposures

(beginning about a mile above Glenora) of grey and blackish, rather cherty quartzites, often nearly on edge. The second consists of slightly indurated conglomerates, sandstones and shales, the conglomerates being often very coarse and containing pebbles both of the older volcanic series and of the granites and granitoid rocks. These lie at comparatively moderate angles of inclination. No fossils were observed in them, but in their lithological character as well as in their position relatively to the Coast Ranges, they resemble rocks of Cretaceous age met with in other parts of British Columbia, both to the south and north of the Stikine, and may be provisionally referred to that period.

Rocks near Telegraph Creek. In the immediate vicinity of Telegraph Creek, the prevalent rock is a grey-green, speckled, altered volcanic material, which proves to be a fine-grained diabase-tuff. * The high hill immediately opposite Telegraph Creek, on the other side of the river, is composed of similar old volcanic rocks, comprising compact diabase and a massive diabase-agglomerate.

Basalt flows. About two miles below Telegraph Creek, on the right bank of the river, a portion of the basaltic filling of the old valley forms a range of columnar cliffs about 200 feet above the present water-level. A second similar remnant occurs just above Telegraph Creek, on the same side, and a portion of it extends up Telegraph Creek itself for a mile or more. Basaltic dykes, which may have served as sources of supply of molten material at the time of eruption, are found cutting the older rocks. Though in some cases simulating the appearance of terraces, the basaltic shelves along the sides of the valley are quite distinct from, and of earlier date than these.

Notes on map. Notes on the various rocks met with will be found on the face of the map accompanying this report. The country to the east of the granitic rocks of the Coast Ranges would require much time and attention before its somewhat complicated geological structure could be properly defined.

Fossiliferous limestone. In the gorge of Telegraph Creek, a large boulder of grey sub-crystalline limestone was found, closely resembling in character and degree of alteration that seen near the "Grand Rapid," but in this case containing large branching corals and numerous *Fusulinæ*, indicating its Carboniferous age. It is of course impossible to state with certainty whence this boulder was derived, but it may very probably have come from the mountains to the north within the drainage-area of Telegraph Creek.

The portion of the Alaskan coast which I have seen, viz., that to the south of the 59th parallel, shows the same general absence of

* See Appendix V. (Stikine No. 25.)

Terraces.

terrace deposits which has already been noted and commented on in the case of the British Columbian coast. In the vicinity of the mouth of the Stikine, terraces fifteen to twenty feet in height are found, resembling the wooded flats met with further up the river, but as they are here upon tide-water, indicating, doubtless, an elevation of the coast-line to that amount. Further up the river, the first appearance of high-level terraces is at about two miles below the Great Glacier. Those here seen are quite narrow, and were estimated to be 500 and 700 feet, respectively, above the river. The river, for the first time, shows bordering-terraces of from thirty to fifty feet in height, about six miles below the Little Cañon, and similar terraces are frequently seen above this point. On the mountain above Glenora a distinct but small terrace was seen from a distance at an estimated height of 1500 feet above the river. At Telegraph Creek the two principal terraces are 90 and 200 feet respectively above the river-level.

Gold.

The mode of occurrence of gold on the Stikine, and the placer mining which has occurred along the river, are described on a subsequent page, in connection with facts on gold mining in the Cassiar region generally. (See p. 79 B.)

Climate.

Two distinct climatic regions.

The traverse of the Coast Ranges by the Stikine River, from its mouth to Telegraph Creek, affords an excellent illustration of the difference between the coast and inland climates, repeating to a great extent the phenomena met with in making a similar traverse of the same ranges in the southern part of British Columbia. It is here, however, all the more remarkable, as so great a difference between these climates would scarcely be anticipated in this northern latitude. Some records of observations in Appendix VI may be referred to for details, but it may be stated here, as showing the broad general contrast, that while the annual precipitation at Wrangell, at the mouth of the Stikine, is over sixty inches,* that in the vicinity of Telegraph Creek on the inland side of the mountains, is so small that it is necessary to irrigate cultivated land.

Nor does this comparison of rain-fall sufficiently mark the great diversity which actually obtains between the two climates, the prevalence of clouded skies in the coast region being accompanied by a saturated state of the atmosphere, while precisely opposite conditions are found on the eastern side of the mountain belt, at not more than

* U S. Coast Pilot, Alaska, Part I, 1883, p. 271. The precipitation at Wrangell is moreover much less than that at more exposed parts of the Coast, for at Tongass and elsewhere it exceeds 100 inches annually.

eighty miles inland from the general line of the coast. The coast climate is, of course, much more temperate than that of the interior, which, even no further off than Telegraph Creek, becomes one of extremes. It is probable that the total annual precipitation is even greater in the vicinity of the culminating and central ranges of the Coast Mountains than at Wrangell, and as a large proportion of this occurs as snow, it sufficiently accounts for the existence of the important glaciers and the heavily snow-covered appearance of the mountains till late in the summer. Miners state that the snow accumulates on the river-flats of the lower part of the Stikine, within the mountains, to a depth of from eight to ten feet, while at Telegraph Creek and on the Tahl-tan River it seldom exceeds eighteeen inches, and at the latter places horses and mules have been wintering out for a number of years. The great depth of snow retards the advance of spring all along the portion of the river where it occurs, and thus by a cumulative effect conserves the already large quantity of snow for the supply of the glaciers, which are consequently due rather to the extremely heavy snow-fall than to the actual latitude of the region.

Bearing of snowfall on existence of glaciers.

When we left the coast, on the 19th of May, the hills near the sea were generally denuded of snow to a height of several hundred feet, but on entering the river patches of snow began to appear on the low flats, and a few miles further on these flats and the gravel-bars of the river were almost entirely covered with the old snow, quite down to the water's edge. The quantity of snow was observed to diminish somewhat where the river first turns to the north, but was again greater in the vicinity of the glaciers, and it was not till the Little Cañon was reached that the flats were found free from snow. From this point on, the improvement in the climate became quite marked, and the limit of snow retreated far up the mountain sides.

Observations on depth of snow.

In correspondence with the above facts, the vegetation is much farther advanced in spring on the inland side of the Coast Ranges than elsewhere. Thus, at the date above mentioned, the cotton-woods and other deciduous trees at the mouth of the Stikine and along its lower part showed merely a general faint greenish tint as the buds opened. Four days later, in the vicinity of Telegraph Creek, the appearance was almost that of early summer. *Shepherdia Canadensis*, *Amalanchier alnifolia*, *Corydalus aurea* var. *occidentalis*, *Actæa spicata* var. *arguta*, *Prunus Virginiana*, *Arnica cordifolia*, *Viburnum pauciflorum*, *Saxifraga tricuspidata*, *Androsace septentrionalis*, amongst other plants, were in flower, and butterflies and humming-birds were abundant.

Climate and vegetation.

The change in species of plants met with in ascending the river is also clearly indicative of that from a very moist to a dry climate, as a reference to the lists in an appendix to this report will show. The

devil's club (*Fatsia horrida*) extends only a few miles above "Kloochman Cañon," while *Elægnus argentea* and other forms characteristic of a dry region were first seen at Telegraph Creek. The state of progress of the season at this place appeared to be nearly, if not quite, equal to that found at a similar date in the vicinity of Ottawa or Montreal.

Local climatic differences.

The local differences of climate are, however, quite important. Thus Glenora, though about twelve miles only from Telegraph Creek, is said to experience much greater cold in winter, and the snow-fall is also greater, being estimated at three feet and a-half. Less snow falls on the Tahl-tan than elsewhere, the amount increasing both to the east and west of that place. Strong winds blowing up stream or inland are prevalent in the Stikine valley in summer, but occur in the reverse direction, as a rule, in winter. Further observations on the winter climate of the Stikine are given in Appendix VI.

Notes at Telegraph Creek.

During the few days spent at Telegraph Creek, in the latter part of May, the wind generally blew up the river and was often strong. The high distant ranges of the Coast Mountains to the west, were usually enveloped in clouds and heavy showers were there evidently of constant occurrance. The sky at Telegraph Creek was also as a rule largely obscured, but after passing over the Coast Mountains the clouds were more broken and produced merely a few drops of rain now and then, the conditions being similar to those met with in the dry country to the east of the same range in the Fraser valley, much further south.

Cultivation.

Cultivation in the vicinity of Telegraph Creek and Glenora is practically confined to the raising of small quantities of vegetables and of barley and fodder for animals. There is, however, in this vicinity, in the aggregate, a considerable area of land which might be tilled if there were sufficient local demand to warrant it. Excellent potatoes are produced, and though the leaves are occasionally touched by frost, the crop is seldom affected. It has further been ascertained by actual trial on a sufficient scale that not only barley, but wheat and oats will ripen, and that all ordinary garden vegetables can be produced. The record is a remarkable one for the 58th degree of north latitude.

Opening and closing of the river.

According to Mr. J. C. Callbreath, of Telegraph Creek, the Stikine generally opens for navigation between April 20th and May 1st.* Ice or 'sludge' usually begins to run in the river about the 1st of November, but has been noted in some years a fortnight earlier. The river generally freezes over before the end of November. Mr. Callbreath

* The season of 1887 was unprecedentedly late, the first canoe from the upper river reaching the coast only on May 18th.

states that the first sludge ice coming down from the smaller tributary mountain streams ceases to appear in the Stikine for a time after these are frozen over. As in the case of other rivers rising in the interior, the highest water occurs in the early summer, generally in June. Horses and mules find grazing on the Tahl-tan from April 20th, or May 1st to about December 1st, after which date they require some hay.

Discovery and Exploration of the Stikine.

Early notices of the river.

Though the position of the Stikine* is indicated on Vancouver's charts by the open channels of the river, and the shoals about its estuary are mapped, the existence of a large river was not recognized by that navigator, who visited this part of the coast in 1793. According to Mr. W. H. Dall,† the river was first found by the fur traders. "The sloop *Dragon*, Captain Cleveland, visited the Stikine delta in April, 1799,‡ and in the journal of the sloop *Eliza*,§ Captain Rowan, for the same year, we find the locality alluded to as 'Stikin'." It was, no doubt, visited as well by many of the trading vessels which about this time frequented the coast. In 1834 the Hudson Bay Company fitted out a vessel named the *Dryad* for the purpose of establishing a post and colony at the mouth of the Stikine, but the Russians being apprised of this circumstance sent two small armed vessels to the spot, and constructed a defensive work which they named Fort Dionysius, on the site of the present town of Wrangell. Finding themselves thus forestalled, the Company retired. This dispute was compromised in 1837, when an arrangement was made by which the Company leased for a term of years all that part of the Russian territory which now constitutes the "coast strip" of Alaska, and the "fort" was handed over to the Company, the British flag being hoisted under a salute of seven guns in June, 1840. In the same year, the post, which had been renamed Fort Stikine by Sir James Douglas, was attacked by the Indians, and in the following year a still more serious attack was threatened, and averted only by the timely arrival of Sir George Simpson, as recorded in his "Narrative of a Journey Round the World" (II, p. 181). In 1847, the coast Indians (Thlinkit) are stated to have attacked and taken possession of the fort. In the spring of 1840, the

Establishments of the Hudson Bay Co.

* The modes of rendering the native name of this river has been very varied. Mr. Dall enumerates *Stakeen*, *Stahkin*, *Stickeen*, *Stachin* and *Stikine*. (Pacific Coast Pilot, Alaska, Part I, 1883 p. 109; foot note.) The last mentioned has been generally employed by good authorities and is adopted here. Mr. J. W. McKay informs me that the name Stikine is a corruption of the native (Thlinkit) word *sta-hane*, meaning "the river," and equivalent to "the great river."

† U. S. Coast Pilot, Alaska, Part I, 1883, p. 110. From this work, and from Bancroft's History of the Pacific Coast, vol. xxxiii, several of the facts mentioned below are also derived.

‡ Cleveland's Voyages, Cambridge, Mass. 1842.

§ MS. in possession of Mr. Dall, but unpublished.

Hudson Bay Company established also a second fort on this part of the coast which was named Fort Durham. This fort was situated at a place named by the late Sir James Douglas, "Locality Inlet," about thirty miles southward from the mouth of Taku River and near the entrance of the Inlet of the same name, in sight of Douglas Island. It was abandoned in the spring of 1843, and is sometimes referred to as Taku Fort.

Dicovery of upper part of river.

Previous to this time, in 1834, Mr. J. McLeod, had in the interest of the Hudson Bay Company, reached the banks of the upper part of the Stikine, near Dease Lake, coming overland from the Mackenzie River. Subsequently, Mr. R. Campbell spent the winter of 1838-39 on Dease Lake, but established no fort on the Stikine.

Discovery of gold.

No further events of importance appear to have occurred in connection with the river till, in 1861, two miners named Choquette ("Buck") and Carpenter, discovered placer gold on its bars. In the following spring, some excitement being created by the announcement of this discovery, several prospecting parties were fitted out in Victoria, and a number of men passed the summer in mining on the river. In 1863, the Russian authorities, hearing of the discovery of gold, despatched the corvette *Rynda* to ascertain whether the mining was being carried on in Russian territory. A boat party from this vessel, under Lieutenant Pereleshin, ascended the river to a point a few miles above the Little Cañon, occupying May 23rd to June 1st on the expedition. Mr. W. P. Blake accompanied this party, and in addition to the sketch-map published by the Russians, his report on the Stikine, previously alluded to, is based on it.*

Hudson Bay Company's post.

A Hudson Bay post was established on the east side of the river in 1862 or 1863 and maintained till about 1874, when it was moved to the vicinity of Glenora, were it remained till 1878, when it was abandoned.

Telegraph exploration.

In 1866, explorations for the line of the Western Union or Collins' Telegraph Company were extended to the Stikine under Major Pope. These were continued in 1867 by Messrs. M. W. Byrnes, Vital Lafleur, W. McNeill and P. J. Leech, and embraced most of the principal tributaries of the river. The results of this work were not separately published, and the whole enterprise of which they were a part was, as is well known, abandoned. The sketch-maps then made were, however, partly embodied in the small map accompanying Mr. W. H. Dall's work on Alaska (1870), and with greater completeness in other subsequent maps of the region. The surveys made at this time, while doubtless sufficient for the object in view, and serving to

* Geographical Notes upon Russian American and the Stickeen River; Washington, 1868. Also, Am. Journ. Sci. and Arts, vol. xliv, 1867, p. 96.

represent the main features of the country traversed in a general way, leave much to be desired in the matter of accuracy.

In 1873, Messrs. Thibert and McCullough, travelling westward from the Mackenzie, discovered gold in the Cassiar region, and fell in with the miners already engaged in placer work on the Stikine in the autumn of that year. The subsequent history of the river depends on that of the Cassiar mining district, and need not be further followed in detail. Subsequent history of the Stikine.

Some years after the acquisition of Alaska by the United States, the Stikine came prominently into public notice for a time in connection with difficulties respecting territorial jurisdiction which occurred in regard to customs and other matters. A full account of these difficulties, together with a report by Mr. J. Hunter of his survey of the lower part of the river, made for the purpose of approximately determining the position of the line of boundary between Alaska and the province of British Columbia, is given in the Canadian Sessional Papers, Vol. XI, No. 11, 1878.*

A description of the Stikine is given in the U. S. Pacific Coast Pilot, previously quoted, as well as an itinerary of the river, but as no correct survey of the Stikine existed at the time (1883), the distances and details are only approximately correct.

Published Maps of the Stikine.

The following reference-list of published maps of the Stikine is based on that given by Mr. Dall in Appendix I to the Coast Pilot of Alaska, 1879.—

Russian Hydrographic Office chart No. 1396, Pacific Ocean on the North-west coast of America (published 1848). Also, Russian chart No. 1493-4 (published 1853), Alexander Archipelago. [These two charts, Mr. Dall informs me, show a part of the Stikine in such a way as to prove that it must have been surveyed.] Russian maps.

Plan of the Stikine River from observations by officers of the corvette *Rynda* in 1863. Russian Hydrographical Department, 1867.

Sketch-map of the Stickeen River from the mouth to the Little Cañon, W. P. Blake, *Op. supra cit.*, 1868. Blake's map.

Map of Cassiar District in Report of Minister of Mines of British Columbia, 1876. [This has remained the most complete map of the river up to the present time, and is a very praiseworthy sketch.] Wright's map.

Plan of Stachine (Stikine) River, by J. Hunter. [This, with other subsidiary maps, is contained in the Sessional Papers, Vol. XI, No. 11, 1878. It includes the lower part of the river only, but is from actual Hunter's map.

* See also Report by W. G. Morris, elsewhere referred to, p. 43 *et seq.*

survey and on a scale of 8000 feet=1 inch. It shows the provisional boundary line adopted without prejudice until the true line shall have been determined.]

Morris' map. Map showing boundary line in Morris' Report on Alaska. U. S. Senate, Ex. Doc. No. 59, 1879.

The river is shown on a small scale, according to the result of surveys here reported on, in a map accompanying a summary of the results of the expedition, in Science, Vol. IX, April 2, 1888.

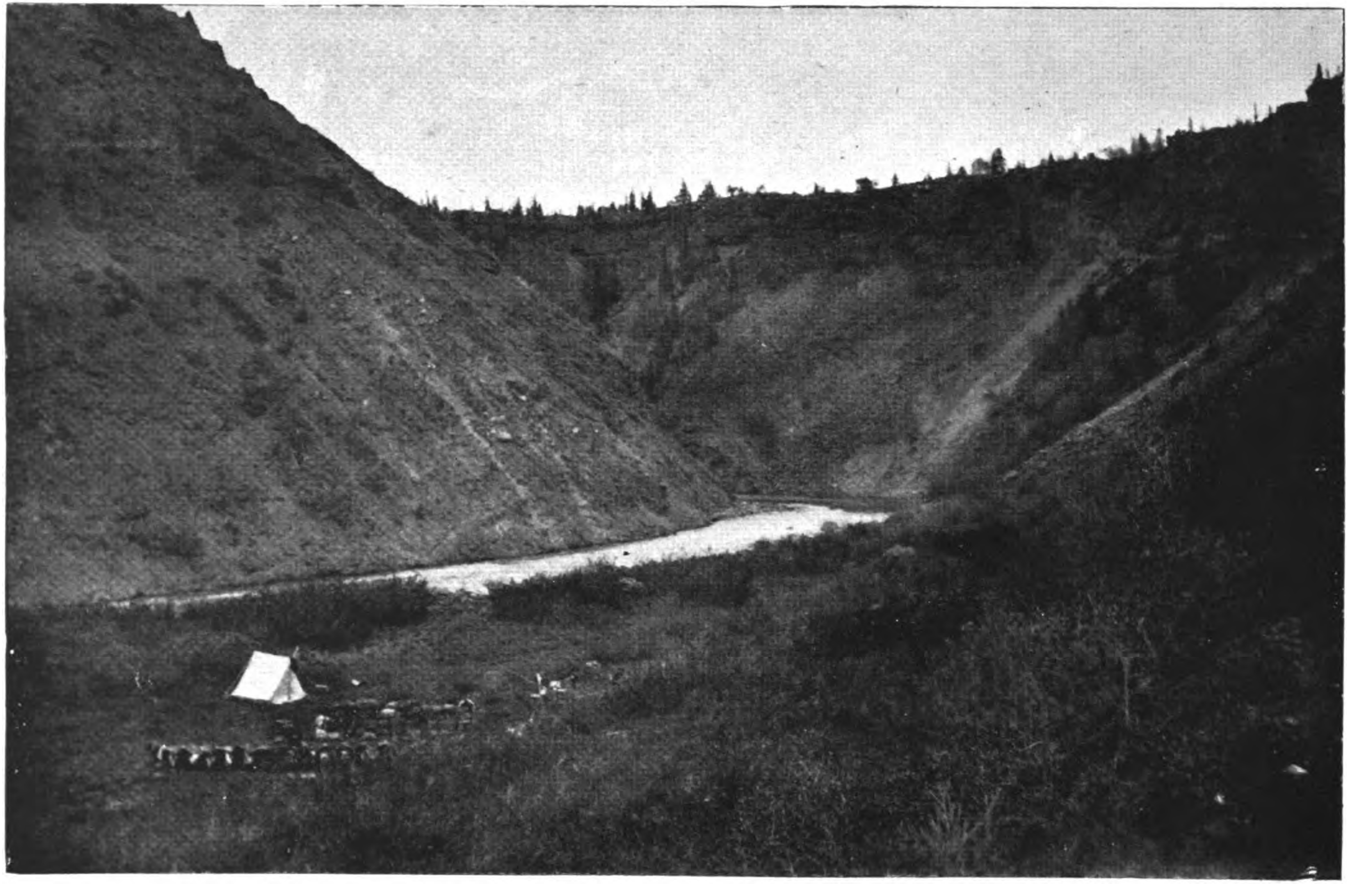
Cassiar Trail* (*Telegraph Creek to Dease Lake.*)

Route followed. The trail from Telegraph Creek to the head of Dease Lake was opened by the Government of British Columbia in 1874. It has since been kept in a fair state of repair, and is a good route for pack animals. It follows the north side of the Stikine and Tanzilla valleys, and is sixty-two miles and a-half in total length As already mentioned, the same important valley which is occupied by the Stikine below Telegraph Creek, continues in a north-eastward direction to Dease Lake, the main stream of the Stikine entering it from the southward about midway between these two points.

Telegraph Creek to Tahl-tan. On leaving Telegraph Creek, the trail makes a steep ascent to the level of a broad terrace, and runs along at a considerable height above the river, and often at some distance from it, till it descends again, at eleven miles, to the valley of the Tahl-tan or First North Fork, near its mouth. The main valley of the Stikine is here about four miles in width, and is bordered by high hills and by mountains of rounded forms, those to the north often nearly bare, while those on the opposite side are generally either wooded or strewn, where fires have passed, with burnt logs. The river occupies a cañon, with precipitous banks often 300 feet in height, which has been cut in the bottom of this great valley. It is very rough and rapid, but there are no true falls. Terraces are well developed at several levels on both sides of the river, which is frequently bordered by vertical basaltic cliffs. The basalts have manifestly filled the bottom of the ancient valley in a series of nearly level flows, which have since been cut through by the present river, while the bordering hills are all composed of much older and probably Palæozoic rocks. A general summary of the geology of the country from Telegraph Creek to Dease Lake is given on a later page.

The country traversed by the trail between Telegraph Creek and the Tahl-tan is wooded only in patches, the trees being chiefly black pine (*Pinus Murrayana*) and aspen (*Populus tremuloides*), with occa-

* See note in Appendix II (p. 196) on the origin of the name Cassiar.



G. M. DAWSON, PHOTO., MAY 31, 1887.

G. E. DESBARATS & SON, ENGRAVERS & PRINTERS, MONTREAL.

TAHL-TAN VALLEY, AT TRAIL-CROSSING.

Bank on the right shews basalt, capping old gravel deposit. Hill on the left composed of older crystalline rocks.

sional specimens of white birch, and alder and willow in the hollows. The soil is reddish and rather sandy, and appears very dry, being but scantily clothed with thin, tufty grass and bear-berry (*Arctostaphylos uva-ursi*). The strawberry (*Fragaria Virginiana*) was abundant and in full flower on May 31st, while *Polemonium pulchellum* was also very conspicuous, and *Linnæa borealis*, *Echinospermum Redowskii* and *Arnica cordifolia* were also locally abundant. Thickets are composed principally of *Shepherdia Canadensis*, high-bush cranberry (*Viburnum pauciflorum*), roses, service-berry (*Amelanchier alnifolia*), red dog wood (*Cornus stolonifera*) and willows.

The Tahl-tan Indian village is seen near the trail, about a mile before the river of the same name is reached, but was at the time we passed quite deserted. **Indian village.**

The Tahl-tan River is crossed near its mouth by a good bridge. It is a large and rapid stream, which rises about thirty miles to the north-westward. Its valley is narrow and almost cañon-like where it reaches the Stikine, and has cut through basalt flows and heavy underlying gravel deposits to a depth of about one hundred and fifty feet, though its right bank, just above the crossing, is composed of the older rocks. It is resorted to by the Indians for salmon fishing during a part of the summer, and there are several temporary houses and a number of graves. The angle between this river and the Stikine, on the right bank, shows three clearly defined, superposed, columnar basalt-flows. The opposite angle, up which the trail zig-zags, is in the form of a long, narrow point, the surface of which is extremely rough, being composed of large pieces of basalt lying in great confusion, with deep interspaces and crevices. This is generally known as the "lava bed," but its broken character appears to have been produced by the washing out of the underlying gravelly deposits, resulting in slides and irregular settlement of a once uniform basalt sheet. Notwithstanding its relatively recent appearance, the basalt here, as elsewhere along the Stikine, is of pre-glacial age, and was found, like the other basalt flows, to pass beneath the higher terraces. Gold mining was at one time carried on successfully for some miles up the Tahl-tan valley. **Tahl-tan River.**

According to M. W. Byrnes, one of the Telegraph Company's explorers, the sources of the Tahl-tan are at a distance of about thirty miles from its confluence with the Stikine. It occupies a portion of an important valley which, still further to the north-westward, carries the upper branches of the Taku and the furthest sources of the Lewes River. The Indians travel along this valley, and it appears worthy of attention as a route from the navigable waters of the Stikine to the Yukon basin. **Sources of Tahl-tan**

Tahl-tan to Tooya.

The distance from the Tahl-tan to the Tooya, or Second North Fork, is about six miles. For about half this distance, to Ward's house, (now, like other places of call along this route abandoned) the trail runs near the Stikine River, the immediate valley of which still continues to be occupied by basaltic flows. Above these, however, the sides of the valley are generally formed of very regular and high terraces, composed of horizontally stratified sands, gravels and earthy deposits, which though generally very fine, are rather silts than true clays. The gravels frequently include large boulders. At Ward's, the trail turns away from the river and cuts across a high point to the Tooya, the highest terrace-level crossed being about 1000 feet above the river. On these high terraces the vegetation was perceptibly less advanced than in the lower parts of the valley. Swampy spots are frequent, and the country, as we recede from the vicinity of the Coast Mountains, has evidently a somewhat more humid climate and is more subject to summer frosts. Potatoes and other crops are successfully grown at Ward's, situated on one of the lower terraces, but irrigation is there necessary.

Tooya valley.

The Tooya valley, where it is crossed by the trail, is a great gorge, about 600 feet in depth, cut out through the terrace deposits. The river, which is spanned by a small bridge, is a wild torrent—almost a series of cascades. Its scarped banks show a section of about 400 feet of the terrace deposits, which are of the character above noted, but include rough, bouldery and gravelly layers, and a number of large granite boulders occur in the bottom of the valley, resembling in their lithogical character the granites of the Coast Ranges.

Sources of Tooya.

Scarcely any authentic information is available regarding the headwaters of the Tooya, though these have been reached by prospectors from Dease Lake. A lake of considerable size is reported to exist on its upper part, as indicated in the accompanying map, and the volume of water in the river is such as to lead to the belief that it must drain a large area to the south of the Yukon watershed.

Plateau beyond Tooya.

About a mile beyond the Tooya, on the summit of a wide, undulating terrace, is Wilson's house. Here turnips and potatoes have been grown, but the potatoes do not fully mature. From Wilson's to Caribou Camp, about twelve miles, the trail crosses an extensive high terrace or plateau, with a nearly level or slightly undulating surface, which is generally wooded with aspen, black pine and white spruce of fair growth. A few very small streams, which flow toward the main valley, are crossed, but the river is generally some miles distant and scarcely visible from the trail. The Tooya valley is here said to run nearly parallel with the main valley of the Stikine and at no great distance from it, but is invisible from the trail. No mountains were

FIG. 2. VIEW OF THE TANZILLA RIVER, LOOKING SOUTH-EASTWARD FROM 'CARIBOU CAMP.'
Illustrating the character of the level terrace-country, based on stratified later-glacial deposits. (From sketch by J. McEvoy.)

here seen to the north-eastward, but high, rounded mountains, with broad, bare summits, continue to border the south-east side of the Stikine valley. About midway between Wilson's and Caribou Camp, the Stikine, or Too-dessa of the Tahl-tan Indians, coming from the southward, enters the main valley, cutting through the bordering mountains in a narrow cañon, which the Indians report impassable. Their route to the upper waters of the river crosses the mountains to the west of this cañon. They state that after again reaching the Stikine, above the cañon, they can ascend it in canoes without difficulty for a long distance.

Head of Stikine.

No rock exposures were seen along this part of the trail, and only occasional groups of boulders. The soil appears to be excellent, but the altitude is probably too great for the successful cultivation of any but the most hardy crops. The vegetation and appearance of the country afford evidence that the climate is still a rather dry one.

Tanzilla.

The trail reaches the edge of the valley of the Tanzilla, or Third North Fork, about a mile south-westward from Caribou Camp. This valley is cut out to a depth of 450 feet below the level of the plateau, and is about a mile in width from rim to rim. The sides show evidence of extensive landslips, both old and recent. The river is a comparatively small though swift and muddy stream, with an estimated width of 180 feet and depth of about three feet. No rocks are exposed in the valley, the entire depth of which appears to be excavated in bedded clays and silts, which weather to grey, earthy slopes. No true boulder-clay was seen, but the occasional presence of large granitic boulders, with the singularly contorted character of some of the clay-beds, appear to indicate the existence of floating ice in the body of water in which the deposits were originally laid down. The clays and silts are evidently the same with those seen in the Tooya, but here, so far as observed, want the rough bouldery and gravelly beds which are there intercalated, and which are doubtless connected with the entry of the former representative of the Tooya into the lake in which the silty deposits have been formed. Flat or lenticular calcareous nodules are abundant at certain horizons in both places, and are also reported to occur at some distance up the Tahl-tan, where the same silty deposit is probably continued. The level country based on these deposits has a width of several miles on both sides of this part of the Tanzilla.

Silt and clay terraces.

From Caribou Camp to the vicinity of Dease Lake, or for about twenty-six miles, the trail runs along the north-west side of the Tanzilla. The valley of the stream gradually loses its depth, owing to the fact that, while the grade of the stream is considerable, the terraces at its sides continue at about the same level. These consist, so far as can be seen, of similar silty and clayey materials, but the edges

Tanzilla valley.

of the terraces are less marked, and they show a tendency to merge into slopes, which rest upon the bases of the mountains bordering the valley. The mountains which extend to the south-east of the river here become higher than before, and take the form of a well-marked range, which is known to the Indians as *Ho-tai'-luh.** Swampy spots become frequent and the vegetation more alpine in character, with evidence of a considerably greater rainfall. The white spruce is relatively more abundant, and *Betula glandulosa* and *Ledum latifolium* were here met with for the first time. A great part of the forest all along this portion of the valley has been destroyed by fire. Rock is seen in place only on approaching the bases of the mountains.

Opposite the head of Dease Lake, the Tanzilla turns off abruptly, and is seen to take its rise in a high range of mountains, holding much snow and running in a north-east and south-west bearing, at a distance of seven or eight miles. The main valley, which has heretofore been occupied by the river, turns northward, through a right-angle, and becomes continuous with that of Dease Lake. The distance from the head of the lake to the Tanzilla, at the nearest point, is about three miles, the level of the Tanzilla being somewhat lower than that of the lake. The height of land is about seventy feet above the lake, or 2730 feet above the sea, and constitutes the watershed between the Arctic and Pacific slopes. **Valley connecting Tanzilla with Dease Lake.**

The part of the valley which connects the Tanzilla with Dease Lake is floored by terrace deposits, and is without doubt very deeply filled with such material, as no solid rock is seen in it. It has evidently been part of a through river-course of very ancient date, but in which direction the stream which originated the valley flowed, it is now difficult to surmise. It has, however, been again occupied by a river in comparatively recent post-glacial times, subsequently to the formation of the terrace deposits, as it is traversed by a well-marked river-bed, filled with rolled stones and gravels. This old channel appears to rise slightly toward Dease Lake, and there can be little doubt that the stream by which it was formed flowed out of the lake. **Origin of the valley.**

Geological Notes on the Cassiar trail.

Respecting the older rocks which characterize the greater part of the country between Telegraph Creek and Dease Lake, few details were noted, and no approach to a general section was obtained, as they are not usually exposed except along the bases of the mountains, which are, as a rule, at some distance from the route of travel. They **Rocks chiefly Palæozoic.**

* The names of geographical features which have not been previously recognised, whether Indian names or names applied by myself, are throughout the descriptive portion of this report printed in italics, on the occasion of their first occurrence.

may be described as consisting of grey and greenish-grey quartzites and grauwackes, with a large proportion of altered volcanic materials, generally felspathic, but passing into diabases and becoming in some cases more or less schistose. Rocks originally of volcanic origin notably preponderate in the vicinity of Telegraph Creek, while near Dease Lake they are less abundant, and at about two miles from the lake, on the trail, massive grey fine-grained limestone occurs, in exposures which are nearly continuous for about a mile. None of the mountains in sight on either side of the valley are distinctly granitic, and rocks of this character were observed only in one locality, where they occupy a relatively small area.

Limestone.

Hornblende-rock and granite.

At about two miles along the trail to the south-west of the Tahl-tan, a dark, blackish-green, highly crystalline hornblende-rock occurs in considerable mass, and is much broken and shattered by a grey porphyritic and hornblendic granite, which appears to be of later date, and which may have a width of about two miles on the trail. In the bed of the Tooya River rocks differing in appearance from any seen elsewhere on this trail were found. They are reddish and purplish in colour, fine-grained, and in some beds slightly porphyritic, and appear to be chiefly felspatic in composition.* One of these is identical with a rock met with in the lower part of the bedded series, a short distance above "Grand Rapid," on the Stikine. No fossils were found in the limestones above alluded to, and the rocks, as a whole, can at present only be classed as Palæozoic, though showing many points in common with those of the Câche Creek group of southern British Columbia, which is believed to be, in great part at least, of Carboniferous age.

Purple felsites.

Basalts filling old river-valley.

The pre-glacial age of the basaltic rocks is shown, as already noted, by their relation to the terraces of the valley, and also by the occurrence upon them of large granitic boulders, the transport of which must be attributed to glacial action. This is seen particularly in some places between Telegraph Creek and the Tahl-tan. The basaltic rocks, at the period of their eruption, have filled the old river-valley, and may very probably have at one time done so continuously from below Glenora to the Tooya, or perhaps considerably further. There is no reason to suppose that the basalts were erupted from a single volcanic centre, and indeed the existence of basaltic dykes cutting the older rocks at Telegraph Creek would appear to lead to an opposite conclusion. Subsequent to the period of basaltic eruption, the river, still flowing in the same great valley, has cut down through the basalts in several places, exposing sections of the gravel deposits of the ancient river. The new channel thus formed is not, however, coincident

* See Appendix V. (Cassiar Trail No. 4.)

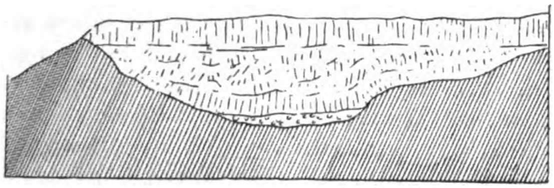


FIG. 3.—SECTION SHOWING OLD RIVER-CHANNEL CAPPED BY BASALTS. EAST BANK STIKINE RIVER BELOW TAHL-TAN.

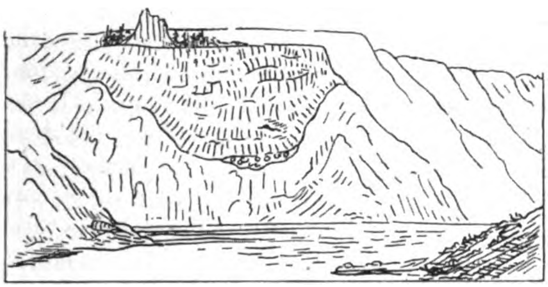


FIG. 4.—SECTION SHOWING OLD RIVER-CHANNEL FILLED WITH BASALT. MOUTH OF TAHL-TAN.

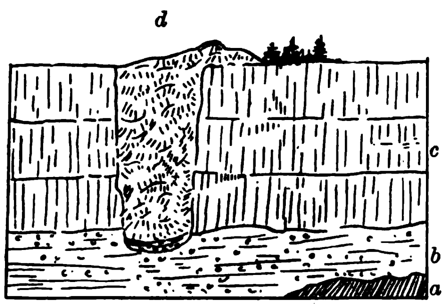


FIG. 5.—SECTION SHOWING RELATIONS OF BASALTS AND GRAVELS. STIKINE RIVER, EAST BANK, ABOVE TAHL-TAN.

a. Old basal rocks.
b. Old gravels.
c. Superposed basalt flows.
d. Basaltic filling of a later gorge.

with the old, but cuts across it at several points, and above Telegraph Creek, the excavation of the new bed has been carried to a depth estimated at from forty to seventy feet below the earlier one.

A few miles below Glenora, where the basalt filling of the old valley has been cut across, it seems, however, that the old river-bed is below the present water-level, indicating, in connection with the previous observation, that the grade of the original river was greater than that of the present.

Basalts near Tahl-tan.

Directly opposite the mouth of the Tahl-tan River, on the left bank of the Stikine, a good section of the old river-bed is exposed, in the truncated end of a point which forms a spur of the plateau to the south, the basalts filling it like a great ingot and resting, at the bottom, on the old gravels, at the sides, directly on the rocky banks of the old channel.

The angle between the Tahl-tan and the Stikine, on the upper side, has already been referred to in connection with the peculiarly disturbed character of the basalt layer by which it is capped. Beneath the basalt at this place is a great thickness (apparently not much less than one hundred feet) of well-rounded gravel and boulders. It is probable that this deposit does not reach to the water-level, but its disintegrated material has formed a slope which conceals any basis of old rocks which may be beneath it. The eruption of basalt has, moreover, not been confined to a single period, but must have occurred at several different times separated by rather wide intervals. The occurrence in some places of three or more superposed flows, shows this to have been the case, but a still more striking proof of the same fact is found in a section observed from a distance, on the left bank of the Stikine above the Tahl-tan. At this place a thick and apparently extensive deposit of gravels has been covered by three superposed basaltic flows. Through these, a narrow vertical-sided cañon has been cut by some tributary stream, which has even excavated a portion of the gravels beneath the lowest basalt. A fourth basaltic flow has then occurred, which has completely filled the cañon and partly overflowed on the surface of the highest of the three earlier basaltic layers.

Basalts of several dates.

Though the basalts of Tertiary age actually seen by me are confined to the Stikine valley, it is highly probable that further explorations will prove their occurrence in other valleys, and possibly also the existence of similar rocks, in the form of plateaux of some size, in the region east of the Coast Ranges.

Old Channel and gold placers.

The basaltic formation of this part of the Stikine has been described in some detail, on account of the importance which it possesses in respect to the distribution of gold. The gold along the Stikine was said by the miners to be "spotted," or irregular, in its occurrence, but the greater part of the "heavy" gold was found just along that

portion of the stream now characterized by the basalts, and it appears even possible to trace a connection between the richer bars which have been worked and those places in which the present river has cut through or followed the old basalt-protected channel. This being the case, it seems very desirable that the old channel should be fully prospected, which I cannot learn has ever been attempted. If gold should be found in it in paying quantity, it might easily be worked, and would give rise to a considerable renewal of activity in mining. It is not known to what extent similar conditions may occur up the Tahl-tan valley, where also remunerative bars were worked some years ago.

Superficial Deposits and Terraces.

No true boulder-clay was recognized either on the Lower Stikine or in the country between Telegraph Creek and Dease Lake; neither were any striated rock surfaces actually seen. The last-mentioned fact is to be attributed to the want of suitable localities for observation in the vicinity of the route followed and to the necessarily cursory character of the examination, as evidence of glaciation of a general character, shown in the rounding of rocky hillocks and the transport of large boulders, is abundant. The most characteristic later formation of the country between Telegraph Creek and Dease Lake, is the silty and clayey deposit which has already been referred to in several places. The whole of the great valley has evidently in later-glacial times been filled with this deposit, which must have been laid down in a comparatively tranquil lake-like body of water, into which coarser material was in some places washed by entering torrents, as in the case of the Tooya. It appears to me possible that this body of water was held in by means of glacier-ice accumulated on the Coast Ranges on one side and those of the Cassiar Mountains on the other, and the increased height of the terraces in the vicinity of Dease Lake, as compared with those near Telegraph Creek, may show that the terrace-deposits have been laid down near the front of a retreating glacier-mass, the water-level of the lake being reduced *pari passu* with its recession. The highest terrace-level observed near the Tahl-tan, is at an approximate elevation of 1700 feet above the sea, while half way between the Tooya and Dease Lake the terraces run up to a height of about 2800 feet. At the head of the lake a well-marked terrace-edge was observed at 520 feet above the lake, or 3180 feet above the sea. The irregular surface of the same terrace sloped upward to a further height of about 100 feet, and granite boulders were found on the summit of a limestone hill 1000 feet above the lake, or 3660 feet above the sea. If the supposition of the considerable inland extension of the glaciers of the Coast Mountains at one epoch of the glacial period be

Boulder-clay not observed.

Thick silty and clayey deposits.

Heights of terraces.

correct (and it is strictly paralleled by similar circumstances in the more southern part of British Columbia), the greater part of the granitic erratics met with may probably have been derived from the Coast Ranges, though the Cassiar Mountains, and possibly other ranges in the region, are characterized by similar rocks.

Route for Waggon-road or Railway.

District naturally easy of access.

Dease Lake is the central point of the Cassiar district, and though, as shown by statistics subsequently quoted, the yield of gold has greatly fallen off since the palmy days of its first discovery, it is very probable that further placer mines of value may yet be found in this region, (of which a great part still remains to be carefully prospected) and there is every reason to believe that quartz mining and other industries will before long be developed on a considerable scale. Even at the present moment this district is more easily accessible than that of Cariboo, and when a waggon-road shall have been built from the head of navigation on the Stikine to Dease Lake, it should be easy to lay down goods at the latter point at very reasonable rates.

Route for waggon road.

The construction of a waggon-road, with moderately favorable grades, between Telegraph Creek and Dease Lake, would not be very difficult or expensive. The first ascent from Telegraph Creek is steep, but might easily be overcome. Between eight aud ten miles from Telegraph Creek, or for a distance of about two miles, the road would have to follow a rough hill-side above the cañon, where some blasting and grading would be required. The descent to the Tahl-tan would entail some heavy side-hill cutting in rock and earth and a bridge would be necessary. The ascent and crossing of the "lava bed" would entail about a mile of rough work on the opposite side of the Tahl-tan, and should the line of the present trail be followed, a long and steep ascent, with grading in gravel and clay, would be required at Ward's, and again in descending to and ascending from the Tooya valley, but no rock work would be necessary. It seems quite probable, however, that a better route might be found for a road, at a lower level, from Ward's to the mouth of the Tooya, in following along the side of the main valley. In either case a good bridge would be required at the Tooya. Beyond this, all the way to Dease Lake, no further serious obstacle is met with. Portions of the route are clayey and swampy, and to render these easily passable, from eight to ten miles of corduroy in all would be required, for which suitable material could be obtained near by in all cases.

Railway route.

Should the construction of a railway be contemplated, the difficulties to be surmounted would be greater in proportion, particularly

between Telegraph Creek and the Tahl-tan, where the line would have to follow the side of the cañon, which is very rough and rocky. Beyond this point, so far as the valley could be seen from the trail, it presents no very serious impediments. Below Telegraph Creek, to Glenora, or a little further, a railway would involve some moderately heavy side-hill work; but further down the Stikine, to the sea, it might follow the river-flats at a nearly uniform level. The greatest difficulty to be apprehended on this part of the line would be that likely to arise in winter from the very heavy snow-fall on that part of the river below the Little Cañon.

It may be pointed out in this connexion that the survey of the Stikine and of the valley leading by the Tanzilla to Dease Lake shows that the route is an exceedingly direct one to Dease Lake, and that, taken in conjunction with the valleys of the Dease and Liard Rivers, it affords almost an air-line from the Pacific Coast to the great Mackenzie River. (See p. 19 B.)

The present rates for goods, from Wrangell to Dease Lake are about as follows:—Wrangell to Telegraph Creek by steamer, $2\frac{1}{2}$ cents per lb. Thence to Dease Lake by pack animals, 6 cents. Thence by lake to Laketon, $\frac{3}{4}$ to 1 cent. Total, about $9\frac{1}{2}$ cents per lb., or $195 per ton. The result of such high prices is to discourage prospecting in the district and seriously to retard its further development. Freight rates.

DEASE LAKE.

We reached the head of Dease Lake on June 5th, and eventually left the lake on the morning of June 19th, spending thus thirteen days in all upon the lake. At the date of our arrival the lake, with the exception of a small area at its head, was still covered with the decayed but unbroken ice of the previous winter, and this did not finally break up and disappear till the 16th. Meanwhile, almost all our time and attention were devoted to sawing out boards and building three boats. It would have been impossible to have left sooner, even if we had had boats ready at the outlet of the lake, which had long been open, in consequence of the entire exhaustion of supplies in the district, from which it was necessary that we should depart provisioned for the greater part of the summer's work. As it was, our boats were finished a few hours before the final disruption of the ice, which occurred in the end with extraordinary rapidity, under the influence of a strong wind. It will easily be understood that we had but little time or opportunity for the examination of the surrounding country, which is nevertheless of considerable interest on account of the rich gold-producing character of some of the streams. Proceedings at Dease Lake.

Opening and closing of lake.

The disappearance of the ice must always be late in this lake, in consequence of its high altitude, the want of any large entering streams and its contracted outlet. It was, however, in 1887 later than ever before known since mining operations began. The following dates, obtained from Mr. Robert Reid, of Laketon, are those of the opening and closing of the lake for the past few years.—

Year.	*Lake opened.*	*Lake closed.*
1882	June 9	December 5 or 6
1883	May 30 (Clear from end to end.)	December 5
1884	June 2	December 2
1885	June 3	December 1 (Frozen completely across.)
1886	June 5	December 16 (Crossing on 17th.)
1887	June 16	

Further particulars respecting the climate of Dease Lake will be found in Appendix VI.

Dease Lake.

Dease Lake has an elevation of 2660 feet above the sea, and lies nearly due north-and-south on the 130th meridian. It has a total length of twenty-four and a-third miles, with an average width of rather less than one mile, being somewhat narrower at the northern than at the southern end. Dease Creek, on the delta of which is situated Laketon, the chief place of the Cassiar district, enters on the west side at sixteen miles and three quarters from the head of the lake, and is the largest tributary stream. It is also the most important, as being that on which the richest of the gold deposits were discovered, and on which gold is still worked to a limited extent. A certain amount of business is still carried on here, and it is the head quarters of the present Gold Commissioner, Mr. Crimp. At the south end, or head of the lake, there are a few buildings, now virtually abandoned, and at Porter's Landing, on the west side of the lake near its north end, goods are landed for Thibert's Creek. The old Hudson Bay Post was situated about two miles from the lower end of the lake, on the east side. A small steamer was put upon the lake when the mines were in a flourishing condition, and is still employed in making occasional trips up or down the lake with supplies.

Mining camps.

Country surrounding the lake.

The country about the lake is everywhere wooded, though trees large enough for lumber are found only in sheltered valleys or on low land. It is not roughly mountainous, though several prominent summits occur. The most conspicuous of these lies four miles back from the lake, about half way between the head of the lake and Laketon. As I could not ascertain that this is recognized by any name, I propose

naming it *McLeod Mountain*, in honour of the discoverer of the lake. Its height is about 6300 feet. Between McLeod Mountain and Dease Creek is *Mount Sullivan*.* not so elevated as the last, but nearer the lake-shore and very conspicuous from it. On the opposite, or east side of the lake, a couple of miles back from the shore, is a group of rounded and wooded mountains, somewhat exceeding 1000 feet in height above the lake, or about 3800 above the sea. *Beady Mountain*, another notable landmark, is also on the east side of the lake, about three miles from its lower end and near the creek of the same name. Its height was not determined, but is less than that of McLeod Mountain. With the exception of these and some other nameless mountains, the country near the lake is merely hilly, or rises in long, light slopes from the shores to undulating wooded uplands, a few hundred feet only above it, which coalesce with the bases of the mountains. Only near the northern end of the lake do the mountains begin to crowd down more closely to the water's edge. The lake is shallow and marshy at both ends, but is elsewhere evidently very deep, though no soundings have been made in it. **Mountains.**

Superficial deposits. Rock-exposures are infrequent along the margin of the lake, which, when scarped, generally shows only stratified, sandy, clayey and gravelly terrace-deposits, like those seen on the trail to the south-eastward. None of these were recognized as true boulder-clay. The lake is probably held in at its northern end by the accumulated delta deposit of Thibert Creek.† It is much constricted, further up, by the similar deposit of Dease Creek, and has narrowly escaped being divided at this place into two lakes. It is rimmed round at its head by somewhat irregular terrace deposits, which have already been alluded to as filling the ancient valley which communicates with that of the Stikine.

Vegetation and cultivation. The vegetation gives evidence of a greater rainfall and conditions more alpine and less favorable than those met with on the trail to the south-eastward, and sharply contrasting with that of Telegraph Creek and the Tahl-tan. The effect of the ice upon the lake in spring, in retarding the vegetation in its immediate vicinity, was extremely apparent. Agriculture can scarcely be regarded as practicable in this region, and the results of gardening, however carefully conducted, are small. Potatoes can be grown, but in some years they are much injured by frost, and carrots, lettuce, cabbage, cauliflowers and turnips may be made to afford a fair return.

Rocks. Such rock-exposures as could be reached near the shores of the lake were inspected, and the material brought down from the hills by sev-

* So named for Mr. J. H. Sullivan, first Gold Commissioner of the district, lost in the wreck of the *Pacific* in 1875.

† A stream about fifty feet wide.

eral streams was examined, the evidence afforded being in favor of the belief that the whole country is underlain by Palæozoic strata resembling those described to the south-eastward. In addition to the limestone already noted as occurring at the head of the lake, there are grey and greenish rocks, representing altered materials of volcanic origin,* associated with leek-green serpentine, in which some minute veins of chrysotile or asbestos were noted. Besides these, and probably predominant as a whole in the valley of the lake, are argillite-schists, which vary from a black plumbaginous to a grey, finely micaceous character, and are often lustrous and not unfrequently highly calcareous. The rocks, as a whole, closely resemble those of parts of the gold bearing series of Cariboo district.

Dease Creek. Dease Creek, is said to be about twelve miles in length and to rise in a lake about five miles long. It has cut a deep, narrow V-shaped valley through a series of terraces, which have evidently been formed at its mouth when the lake stood at various levels higher than the present. The ancient pre-glacial valley has, at the same later-glacial period, been filled with clayey and gravelly deposits, among which large and often glaciated boulders are common. These deposits frequently resemble boulder-clay, and are possibly entitled to be so called. The present valley has been cut down through them, and often to a considerable depth into the rock beneath them. The mining has occurred chiefly in the bed of the stream, along the surface of the solid rock, in the sides of the valley, and in various places in the gravel deposits which still remain; also at the head of the flat on which Laketon stands, where the stream issues from the narrow recent valley. Much quartz occurs in the wash of the stream, and the gold, being "coarse," is evidently of local origin and has been liberated by the disintegration of the rocks in the immediate vicinity of, if not entirely within, the actual drainage-area of the stream.

GOLD MINING IN CASSIAR DISTRICT.

Yield of gold. The following table, based on the reports of the Minister of Mines of British Columbia, clearly illustrates the sudden rise and gradual decadence of the gold yield of Cassiar district.—

Estimated value of Gold produced by Cassiar District, from 1874 *to* 1887.

1873	Not known.
1874	$1,000,000
1875	830,000

* One of these, representing a numerous class having a more or less distinct schistose structure, is described in Appendix V. (Dease Lake, No. 8.)

1876	556,474
1877	499,830
1878	519,720
1879	405,200
1880	297,850
1881	198,900
1882	182,800
1883	119,000
1884	101,600
1885	50,600
1886	63,610
1887	60,485
Total	$4,886,069

No estimate has been formed for the yield of the mines in the first year of their operation (1873,) but as that for the following year appears probably to be overstated, it may, for the purpose of arriving at a general estimate of the whole, be assumed that the sum of one million includes both years. The value of the gold may be stated as from $16 to $17 per ounce, though that of Dease Creek is usually priced at about $15·50 only.

In the Report of Progress of the Geological Survey for 1886-87, I was enabled to give a general note on the various creeks worked for gold in Cassiar and on the Stikine.* The information there given was chiefly furnished by Mr. G. B. Wright. I am now able to add to this, particulars as to the actual condition of the workings in 1887. These were largely obtained through the kindness of Mr. J. S. Crimp, the present Gold Commissioner for Cassiar district, though facts were also gathered from several old miners who were among the first to enter the country. As explained on a previous page, my opportunities of personally investigating the Cassiar district were restricted by the necessity we were under of pushing on to our main field of exploration. Chiefly from the sources above-mentioned the following summary account of the different localities is derived. Sources of information on mining.

Summary of Facts relating to Gold on the Stikine and various Creeks in the Cassiar District (1887).

Stikine River.—Gold discovered, 1861. Very fine gold can be found on almost all parts of the river, but very little profitable work was ever done below the mouth of the Clearwater. The rich ground may be said to have begun about nine miles below Glenora, and to have extended thence to the Grand Cañon, above Telegraph Creek. Here Sheck's or Shake's Bar, and Carpenter's, Fiddler's and Buck's Localities of gold mining.

* *Op. cit.*, pp. 138-140.

Localites of gold mining, continued.

Bars were situated, the richest being between Glenora and Telegraph Creek, though gold was also worked in a few places in the Grand Cañon. With the exception of a few spots in the lower part of the cañon, below the Tahl-tan, and one nearly opposite Wilson's, all the gold was very fine. Coarse gold was also found on the lower part of the Tahl-tan, which proved quite profitable, and bars were worked for a distance of ten or fifteen miles up the river. Pellets supposed to be of silver but probably of arquerite or silver-amalgam were also found on the Tahl-tan. The bars on the Stikine at first averaged $3 to $10 a day to the hand, and as much as two to three ounces was sometimes obtained, but not more than $1 to $3 can now be got, and work has practically ceased. It is stated that none of the higher benches so far prospected will pay for hydraulic work, but it is doubtful whether these have been examined with sufficient care, as the area of such benches is very considerablo.

Dease Creek.—The bed of this creek has been gone over several times, and is now nearly worked out. It formerly yielded $8 to $50 a day to the hand, and paid well from the head of the flat, at its mouth, for six miles up. Above this a few isolated good claims were found, particularly the Cariboo Company's claim, eight miles up, from which much heavy gold was obtained. This claim has been worked over four times. The best remaining claims are bench claims on the south side of the creek, some of these being upon an old high channel which yields well in places. Some hydraulic work on a small scale is being carried on. In 1886 there were sixteen whites and thirty-five Chinese at work, and the total amount produced was about $15,000. The gold is generally well water-worn and somewhat mixed in character, varying in value from $15·50 to $16 per ounce.

Thibert Creek.—The bed of this stream is also worked out. It paid for about six miles up from the mouth, yielding at about the same rate as the last. Bench claims are now being worked, two by the hydraulic method, the rest by tunnelling. An old high channel had also been found on the south side of this creek, upon which two claims are being worked, one paying very well. Yield in 1886, nearly the same with Dease Creek, about twenty-two whites and twenty-five Chinese being employed. Gold valued at $16 per ounce. On a tributary named Mosquito Creek very good prospects have lately been obtained,—as much as $40 to a six-foot set of timbers. Work is now going on here.

Defot Creek.—A tributary of Cañon Creek, on the same (west) side of Dease River with the last. It rises on a plateau high above the river, where great numbers of quartz reefs occur, and the gold found is quite rough and full of quartz. Large nuggets have been obtained, including one of fourteen ounces in weight. Some work is still in

progress, though the creek-bed is worked out. Gold worth $17 per ounce.

Localities of gold mining. continued.

Cañon Creek.—No paying deposits found.

Cottonwood Creek.—This large stream heads in the same mountains with the last, but no paying deposits have been found upon it.

Beady Creek.—A little mining was done here in 1874 and 1875, but nothing of importance ever found.

Eagle River.—No mining ever developed.

McDame Creek.—Discovered 1874. The highest average daily yield varied from $6 to $100 to the hand when mining was at its best. Most of the gold was obtained in what appeared to be an old high-level channel, which crossed points of terraces or benches on both sides of the present stream. A very small proportion of the yield was from the stream-bed. Four or five Whites and forty Chinese are now at work here, the greater number of the Chinese being employed on wide flats, which occur about nine miles up the creek. Bench claims run for about seven miles up the creek or to Holloway's Bar. Gold worth from $17·75 to $18 per ounce.

Snow Creek, a tributary of the last.—The richest claim found in Cassiar was near the mouth of this creek, yielding for a week 300 ounces for six to eight men. Only two men now at work.

Quartz Creek, a branch of Trout Creek, which is also a tributary of McDame Creek. Good claims were worked here, yielding rough gold full of quartz. Much quartz in the vicinity. Two miners now at work.

Rosella Patterson and Dennis Creeks.—Yielded moderate amounts of gold, paying "wages," say, at $6 a day. Now abandoned.

The remaining creeks mentioned in the report cited, *viz.*, *Gold Creek*, *Slate Creek*, *Somer's Creek* or *First North Fork of McDame*, *Third North Fork of McDame*, *Spring Creek* and *Fall Creek*, are now abandoned, though several of them yielded a considerable amount of gold at one time.

Sayyea Creek. Near the head-waters of the Upper Liard, yielded excellent prospects, but has never been properly examined. The gold obtained was found in the benches, and some of it was very coarse. The creek yielded at the rate of $10·90 a day to the hand for a short time, to three miners who discovered it.

Walker Creek.—Said to be distant about seventy miles in an easterly direction from the mouth of McDame Creek. Some work has been done here, but no great quantity of gold obtained.

Black, Turnagain or "Muddy" River.—Reached by trail running easterly from a point opposite the mouth of McDame Creek, and said to be ninety miles distant. Fine gold stated to have been obtained to the value of $20 per day to the hand, and it is generally believed that coarse

gold may occur on its head-waters. In 1874 prospectors found streams about seventy miles south-east of Dease Lake, which are supposed to be tributaries of this river, and yielded $6 a day in coarse gold, but at the time this was considered too poor to work.

Frozen ground.

Considerable difficulties were experienced in mining operations in some parts of the Cassiar district on account of frozen ground, often met with below the wooded and mossy surface. It is on record that on Dease Creek, the ground continued to be frozen to the end of a tunnel driven in one hundred and fifty feet from the slope of the hill, and at a depth of forty feet from the surface. After the woods and moss had, however, been burnt off, little further complaint was heard of frozen ground.

Metalliferous veins.

Very little has yet been done in the way of prospecting for metalliferous veins in this district, but from what I have been able to learn it would well repay a thorough examination, and the comparative ease with which it may be reached from the coast, together with the facility it affords for the construction of a good road to the very centre of the district, should not be forgotten. A specimen of galena, holding a little copper and iron pyrites, from the "Acadia Claim," South Fork of McDame Creek, was given to me some years ago by Mr. J. W. McKay. This has since been assayed by Mr. C. Hoffmann, and proves to contain 75 ounces of silver to the ton of 2000 lbs. A piece of native copper, fifteen pounds in weight, was at one time found in Boulder Gulch, Thibert Creek.

Prospects of further placer mining.

Taking into consideration the great extent of generally auriferous country included in the Cassiar district, it must be conceded, that apart from the immediate vicinity of the well known productive camps, it has been very imperfectly prospected. A great part of the district has in fact merely been run over in search of rich diggings, the simplest and cheapest methods of prospecting only, having been employed in the quest. It is not improbable that additional rich creeks like those of the vicinity of Dease Lake, may yet be discovered elsewhere and it may be considered certain that these are great areas of poorer deposits which will pay to work with improved methods, and will eventually be utilized. It is also to be anticipated that "quartz mining" will ere long be inaugurated and will afford a more permanent basis of prosperity than alluvial mining, however rich.

Discovery and Exploration of Cassiar District.

Discovery.

The Cassiar district of the northern interior of British Columbia may be said to have been twice discovered, first by officers and employees of the Hudson Bay Company, and again, after a considerable interval, by the gold miners.

Exploration by McLeod.

The unsuccessful attempt made by the Hudson Bay Company in 1834, to reach the trade of the interior country west of the Rocky Mountains from the mouth of the Stikine, has already been noted. (p. 61 B). Efforts were at the same time being made to open up routes from the eastward. In the summer of 1834 Mr. J. McLeod, chief trader, was employed exploring the Liard River above Fort Halkett, and in endeavoring to discover some stream flowing to the westward. He found and named Dease Lake,* crossed to the head-waters of the Stikine, which he proposed to name the "Pelly River," and travelled westward in the valley apparently as far as the Tooya or Second North Fork. The Indian bridge (afterwards named Terror Bridge by Mr. R. Campbell), by which this river was crossed at the foot of "Thomas' Fall," was of such a character that neither McLeod nor any of his eight men dared to attempt it, and from this point he and his party retraced their steps.

McLeod's route and map.

The geographical information obtained by McLeod is incorporated in Arrowsmith's map of 1850, on which, however, the upper part of the Stikine, which McLeod had proposed to call the Pelly, is named "Frances River," and is placed much too far north and is not connected with the Stikine. The name Frances is still retained as an alternative one to "Stikeen" on the edition of 1854, though it has since fallen entirely into disuse. McLeod's route from the head of Dease Lake, as shown on these maps, crossed the Tanzilla within a few miles of the lake, and followed its left bank, recrossing before the main Stikine enters the valley, probably by an Indian suspension bridge, which is reported still to exist, within a mile or two of this point. On careful consideration of the facts there can scarcely be any doubt that the Tooya River was McLeod's furthest point, and the Indian bridge probably crossed it near the position of the present bridge, though it may have been at some point further up the stream which has not yet been mapped.

Second abortive expedition

In 1836, McLeod's successor at Fort Halkett was instructed to establish a post across the mountains and to extend the trade down the Stikine, or "Pelly," as it was then called from McLeod's naming. For this purpose he left Fort Halkett early in June, with a party of men and two large canoes, but the expedition entirely miscarried. The appearance, or reported appearance, of a large force of hostile Indians at Portage Brulé, ten miles above Fort Halkett, so alarmed the party that they turned back in great haste, abandoning their goods, and lost no time in running down stream to Fort Simpson.

* Dease Lake and River were so named by McLeod after Peter Warren Dease, the Arctic explorer.

Exploration by Campbell.

For most of the above particulars I am indebted to Mr. Robert Campbell, who was at the time of the return of the last-mentioned party in temporary charge of Fort Simpson. The news brought back by these expeditions was of a character to discourage further enterprises in the region, the extremely difficult and dangerous navigation of the Liard River, which constituted the avenue of approach from the Mackenzie, being an additional deterrent. In 1838, however, Mr. R. Campbell volunteered his services to establish a trading post at Dease Lake, and in the spring of that year succeeded in doing so. He was accompanied by a half-breed and two Indian lads only. After ascertaining that the "Pelly" of McLeod was identical with the Stikine, he returned to Dease Lake, where, to employ his own words, "we passed a winter of constant danger from the savage Russian [coast] Indians, and of much suffering from starvation. We were dependent for subsistance on what animals we could catch, and, failing that, on '*tripe de roche.*' We were at one time reduced to such dire straits that we were obliged to eat our parchment windows, and our last meal before abondoning Dease Lake, on 8th May, 1839, consisted of the lacing of our snow-shoes."* After being thus abandoned, the post was not again re-occupied. It had become unnecessary, owing to the leasing of the "coast strip" of Russian America by Sir George Simpson for the Company, in consequence of which the trade of the interior was entirely controlled on both sides by the Company.

Further history

From this time the country appears to have been practically forgotten for many years. The furs produced by it found their way, through the Coast Indians down the Stikine, by the Liard to the Hudson Bay posts on that stream, or across country southward to Fort Connelly (established by Douglas in 1826), on Bear Lake, at the head of the Skeena River. The exploration of the Telegraph Survey in 1866-67, has already been referred to. It did not extend inland as far as Dease Lake.

Gold discovery.

Such was the state of the Cassiar district when Messrs. Thibert and McCulloch, by the discovery of gold in 1872, brought about an entire change in its conditions. Henry Thibert, a French-Canadian, left the Red River country in 1869 on a hunting and respecting expedition to the west. In 1871 he met McCulloch, a Scotchman, and together they passed the winter near the abandoned site of Fort Halkett, on the Liard River, suffering no ordinary hardships from scarcity of food. Near this place, probably on what was known afterwards as McCulloch's Bar, gold was first found. In 1872 they reached Dease Lake, having been informed that it was a good locality for fish, with the intention

* The Discovery and Exploration of the Yucon (Pelly) River. Winnipeg, 1885.

of securing a sufficient supply for the ensuing winter. Being told, however, by the Indians, that white men were engaged in mining on the Stikine not far off, they crossed by the trail from the head of the lake and reached the mining camp of Buck's Bar. Early in 1873 they set out on their return to the original discovery of gold, but meeting with success on Thibert's Creek, at the lower end of the lake, they were deterred from going further and remained working there during the summer, being joined afterwards by thirteen other miners from the Stikine. Dease Creek was discovered during the same season, and Capt. W. Moore was among the first to begin work there. Thibert is still mining in Cassiar, but McCulloch lost his life some years since on a winter journey on the Stikine.

The subsequent history of Cassiar is that of a mining district.

In 1874 the population, exclusive of Indians, was estimated to have reached 1500. The placers of McDame Creek were discovered. Miners descended the Liard a long distance, and worked McCulloch's Bar and other river-bars. Prospectors ascended the same river, and reported having been within sight of Frances Lake. The little town of Laketon was built at the mouth of Dease Creek, and beef cattle were for the first time brought across country from the Upper Fraser. The total yield of gold from the district (which, from a mining point of view, includes the Stikine) is roughly estimated to have been equal to $1,000,000. Gold mining, 1874.

In 1875 the population is estimated to have been 1081, and the yield of gold equalled about $830,000. Three hundred head of cattle were brought from the Fraser overland. This and the preceding season were the best years of the district. Of a small party which spent the winter of 1874-75 far up the Liard River, four died of scurvy. Prospecting was actively carried on in outlying regions, Sayyea Creek being discovered near the Liard head-waters, and the Frances River also apparently examined. 1875.

Owing to the flattering accounts sent out, a great influx of miners occurred in 1876, the population being at one time estimated at 2000. Profitable work could not, however, be found for so many men, and the yield of gold fell to $499,830. Walker Creek, said to be seventy to eighty miles east of McDame Creek, was discovered, but this stream never proved very remunerative. Defot Creek was also found, and in 1878 proved rich for a limited area. 1876.

Since this time the production of the district and the number of miners employed have gradually declined, and no important new creeks have been discovered, though reports to that effect have from time to time been circulated. The Black or Turnagain (Muddy) River is the most recent of these, some attention being drawn to it in 1886. Decline of gold mining.

It appears, indeed, that after the first few years very little prospecting or exploring has been done at a distance from the main creeks, of which Dease, Thibert and McDame have throughout been the most important and permanently productive.

DEASE RIVER.

We left Dease Lake with quite a little flotilla, consisting of the three boats we had built, with an Osgood canvass boat, which it had been intended to keep in reserve, but which the amount of dead weight which we had to carry obliged us to press into the service. Besides myself, the party consisted of Messrs. McConnell and McEvoy, four white men, five Coast Indians and one Indian woman, the wife of the leading Indian boatman.

Cassiar Range. Though the region about Dease Lake is as a whole rather low, with isolated mountains and ridges here and there prominent, that to the east and north-east is very different, being studded with rugged mountains, and in effect constituting an important mountain range with north-west and south-east trend, and a transverse width of nearly fifty miles. This range appears to represent a continuation of that which in various maps has been named the Peak Mountains or Blue Mountains, but as its connection to the south-eastward is as yet quite uncertain, and as neither of these names possesses either a distinctive character or any special fitness, I believe it will be most appropriate and convenient to call the range the *Cassiar Range,* and shall accordingly so designate it.

Lower end of Dease Lake. Looking down the Dease River from Porter's Landing, near the north end of the lake, the view is one of the most picturesque possible, embracing a portion of the lake itself, bordered by the marshy flats of the mouth of Thibert Creek and bounded by the rugged and extremely varied forms of the eastern ridges of these mountains, towards which the Dease River flows, and through which it cuts in a direction almost directly transverse to the run of the range.

Three main courses of the Dease. The Dease River has, up to the present time, been very inaccurately represented upon the maps. My survey of the river, as shown on the accompanying map, proves that its course is somewhat remarkable. Disregarding minor flexures, which are numerous and sometimes involved, it may be described as following three principal directions.—From Dease Lake its general course is N. 50° E. for forty-seven miles, to a point near the valley of Rapid River. Here, before it has freed itself from the Cassiar Range, it turns nearly at a right-angle to a bearing of N. 15° W., which it maintains for thirty-one miles. Thence it again turns for a second time through a right-angle to a course of

N. 55° E., which it follows to its junction with the Liard. Its entire length, thus measured in three straight reaches, is one hundred and ten miles, but measured in straight lengths of one mile it is one hundred and twenty-seven miles, or, following all the sinuosities of the stream, one hundred and eighty miles.

Fall of the river, and current.

The height of Dease Lake, as previously stated, is 2660 feet, within small limits of error. That of the confluence of the Dease and Liard about 2100 feet. The last mentioned elevation is a fair approximation only, as no simultaneous barometer readings were available for purposes of comparison, and the weather during our stay at the forks was rather unsettled. The total fall of the river, according to these figures, is 560 feet, giving a slope of four feet to the mile for its entire length, which, judging from analogy with other western rivers, is about what might be expected from the appearance of the stream. The velocity of the current was estimated at about three miles an hour, as a general average, but there are several little rapids, as well as some rather long tranquil reaches.

Navigability of the river.

The river, from Dease Lake to the Liard, may easily be descended in two days, but the ascent is a comparatively slow process, depending much on the height of the water, and when the bars and beaches are not bare for tracking is a tedious affair. It is possible that the river might be navigated by small stern-wheel steamers of good power, as there are no insuperable obstacles, but doubtful whether such an enterprise would be a remunerative one, even if the traffic were to assume proportions much greater than at present. Such goods as are now required at McDame Creek (fifty-five and a-half miles below Dease Lake by the course of the stream) and at the little trading post at the mouth of the river, are easily taken down stream in large flat-bottomed boats, which go back light, by poling and tracking, without great difficulty. The boating on the river has been done principally by crews of Coast Indians, who are engaged and brought into the interior for the purpose.

Upper part of the river.

On leaving Dease Lake, the river is a small stream, estimated to average from 100 to 150 feet only in width, with a general middle depth of about three feet. It is extremely tortuous and rather swift, meandering in a wide, flat valley. At about eight miles from the lake, it may be said distinctly to enter the mountains, the valley at the same time gradually narrowing and becoming bordered by mountains from 4500 to 5000 feet in height, which, on the 19th of June, still bore much snow on their summits. At about thirteen miles from Dease Lake, it expands into a little lake about a mile and three-quarters in length, and between this and the mouth of Cottonwood Creek it flows through three more similar lake-like expansions, which are, respectively, a mile and a half, two miles and one mile in length. These are probably formed

in all cases by the partial blocking of the valley by *débris* brought in by tributary streams, of which Cottonwood Creek itself is the last and most important. These lakes constitute somewhat serious impediments to navigation, as they freeze over in the autumn long before the ice takes on the river, and remain frozen till late in the spring.

Small lakes. The mountains by which the valley is hemmed in on both sides from *First Lake* to the Cottonwood are very rough and high, and chiefly, if not entirely, composed of granitoid rocks. About three miles and a-half north-west of *Second Lake* is a remarkable broken summit, with a height estimated at 7500 feet, which, from the peculiarity of its form, has been named *Anvil Mountain*. Running parallel with this and *Third Lake* is a straight, well-defined range, the higher peaks of which attain an equal elevation, and which, for the sake of distinction and in consequence of the long slopes of broken rocks which descend from it, has been indicated on the map as the *Skree Range*. It is probable that actual measurement will show that several of the peaks in this vicinity exceed 8000 feet. The vegetation was observed to be further advanced as soon as the Dease River was fairly entered, showing how great must be the effect of the ice which lingers on Dease Lake, in its immediate vicinity. There is also evidence of a less abundant rain-fall along the river.

Tributaries. Dease River rapidly increases in size, and after the lake is left, soon doubles its volume, owing to the number of affluent streams, of which Cottonwood Creek is the first which may be called a river. This stream occupies an important valley, which may be observed to run for many miles in a north-westward direction, bordered by continuous high ranges. It is remarkable that no paying deposits of gold have ever been found either on this or on Eagle River, which enters the Dease from the south about four miles further down. Eagle River also flows between high mountains, and its valley appears to be parallel to, and analogous with, that occupied by Dease Lake. It is evidently the "Christie River" of McLeod,* but this name has entirely passed out of use, and it appears hopeless to endeavor to reinstate it. Cottonwood Creek is shown on Arrowsmith's maps, according to McLeod and Campbell, but is not named.

Terraces. Rock exposures are unfrequent in the banks of the portion of Dease River above described, though stratified gravel deposits are often cut into. There is also a considerable development of terraces at high levels on the sides of some of the mountains, particularly in the part of the valley which runs along the base of the Skree Range. Well-

* I have endeavored in all cases to identify the original names given by the first explorers in this country, and to ascertain as well the native names of places, but where these have passed entirely out of use by the miners and traders now in the country, it becomes necessary to drop them, though in so doing the strict law of priority is, no doubt, transgressed.

marked terraces were here seen on the west side of the valley, at an estimated height of 2000 feet above the river, or about 4600 feet above the sea.

Cottonwood Creek to McDame.

Immediately below the mouth of Cottonwood Creek is the Cottonwood Rapid, in which the course of the river is impeded by a number of boulders. The rapid is not a formidable one, or at all dangerous to run, with ordinary care. The river below Cottonwood Creek runs nearly due east for about ten miles, with a rather strong current. It then turns more to the northward, and after making several large flexures, reaches Sylvester's Landing, at the mouth of McDame Creek, in about eight miles. In this reach the current is slack, and the river averages 300 feet in width. The flat land of the river-valley is rather wide in this part of its length, but the mountains to the north and south are high and bold, many of the summits ranging from 6000 to 7000 feet. The lower slopes of the mountains are usually light, and in general thickly wooded, but their higher parts are treeless, and from the quantity of snow borne by them in June, must retain some snow throughout the summer. Immediately opposite the mouth of McDame Creek is a remarkably prominent and abrupt rocky mountain, which it is proposed to name *Sylvester Peak*. It height was estimated at 7000 feet, but the circumstances did not admit of its measurement.

Sylvester's Landing.

Sylvester's Landing is the point of supply for the miners on McDame Creek, also a post for Indian trade, and there are here a few log-houses and store buildings. Mr. R. Sylvester has been resident here for a number of years, and readily gave us all the information and advice in his power. McDame Creek was discovered to be auriferous in 1874. It has since been constantly worked, and, with its tributaries, has yielded much gold, but is now believed to be nearly exhausted. Its valley is wide and important, running north-westward for about seven miles, and then turning nearly due west. At the angle thus formed a low, wide pass leads through the mountains to the north-eastward, where it connects with the valley of the Dease. The appearance of this pass, as seen from a distance, is such as to suggest that the Dease River itself may at some former period have flowed through it.

McDame Creek Mountains.

The mountains bordering McDame Creek, viewed from Sylvester's Landing, are singularly different from any before met with. They are evidently composed for the most part of limestone, and characterized by the occurrence of long, bare slopes of shattered rock-fragments. They are scarcely at all wooded, and in this respect resemble the bare limestone crests of parts of the Rocky Mountains in more southern latitudes.

Cultivation.

Potatoes and turnips of large size are grown every season without difficulty on McDame Creek.

Tributaries below McDame

Nine miles below Sylvester's, the Dease makes its great bend toward the north, the intervening portion of the river somewhat changing its character from that above described, rock exposures being comparatively frequent in its banks and bed, where they produce several little rapids. Four-mile Creek enters from the south at somewhat less than the specified distance below Sylvester's. It appears to be the "Stuart River" of McLeod, shown on Arrowsmith's map of 1850, but neither on this nor on that of 1854 is McDame Creek indicated. Sylvester's trail to Turnagain or Black River (Muddy River of miners) runs up this valley, and follows a tributary—Sheep Creek—to the south-eastward, passing near the base of *Sheep Mountain*, a high rugged peak estimated at 8000 feet, situated about five miles and a-half south of the Dease. The distance to the trading outpost on Turnagain River is estimated at ninety miles, but is probably less. Horses are employed in packing over the trail.

Trail to Black River.

Rapid River.

The valley of the Rapid River joins that of the Dease at its great bend, just alluded to, but the stream, running parallel with the Dease for some distance, enters it several miles lower down, and its actual confluence was not observed. Beyond the great bend the mountains near the river decrease rather notably in height and abruptness, and at the same time retreat from the vicinity of the river, the valley becoming very wide, and long, hummocky slopes, or groups of low hills, coming in between the river and the mountains.

Dry belt east of Cassiar Mountains.

The northerly course of the river here carries it very obliquely through the eastern portion of the Cassiar Range. The precipitation in this part of the valley is evidently inconsiderable. The quantity of snow resting upon the mountains was observed to be very small, and here Sylvester successfully winters his horses, without cutting hay or otherwise providing for them, the depth of snow in winter being so small that it does not seriously interfere with grazing. This favored district is, in fact, homologous with that in the vicinity of Telegraph Creek, being in the dry lee of the Cassiar Range, just as that is in a similar situation with respect to the Coast Mountains. Much of the valley, with the slopes of the hills, is open or partially wooded with groves of black pine (*P. Murrayana*) and aspen poplar. The grass has the tussocky bunch-grass character usually found in dry regions, and it is intermixed with the small sage (*Artemisia frigida*). The bear-berry (*Arctostaphlyos uva-ursi*) is not uncommon, and the strawberry and lupin (*Lupinus Nootkatensis*) were in flower. *Anemone patens* was here also observed for the first time, but long past flowering. Making allowance for the time occupied in reaching this place from Telegraph Creek, the progress of vegetation here was palpably less advanced, but the showing was still a remarkable one for the latitude, elevation and distance from the sea of the region.

Below the Rapid River the Dease changes its character considerably, becoming relatively wide, with numerous gravel-bars, and in some places many islands, with frequent "drift piles" or accumulations of timber. Terraces are well shown on the sides of the mountains and reach a height of about 2000 feet above the river. Dease below Rapid River.

A few miles before reaching the second great bend, a stream joins from the west, which has become known to the miners as French Creek, and is probably the "Detour River" of old maps. It rises on the north-east slope of the Cassiar Mountains, and is not large. French Creek.

The last main reach of the Dease is that which extends from the second great bend to its mouth, a distance of thirty-one miles in a direction of N. 55° E. Though the course of the river is far from being direct, the general bearing leaves the base of the Cassiar Range nearly at a right-angle. The country becomes low and uninteresting, and assumes a rather dreary aspect, being covered generally with forest of inferior growth, often degenerating into swamp on northern aspects, and with only occasional grassy openings on slopes with sunny exposures. In descending this part of the river, the mountains soon become invisible from the river-valley, which is bordered by undulating lowlands, or low diffuse hills which rise to a plateau at some miles distant, from 400 to 500 feet above the stream. Banks of frozen soil were seen in one or two places beneath a peaty or mossy covering. The climate is evidently somewhat more humid than before and less favorable to vegetation. The current of the river is rather swift, and there are two or three inconsiderable rapids, but none of importance till within about four miles of the mouth, where there are several strong rapids, which at certain stages of the water are reported to be dangerous, and in which all our boats shipped more or less water. Terraces, as much as 300 feet in height, approach the river in some places in this part of its course, and when cut into generally show stratified gravels which sometimes rest directly on low exposures of rock. Lower part of the Dease.

The larch (*Larix Americana*) was first seen five miles below the second great bend, and below this place becomes quite abundant in cold, swampy spots, where it grows with the black spruce (*Picea nigra.*) Larch.

Blue River (the "Caribou River" of Campbell) joins the Dease twelve miles below the second great bend. It is a stream fifty feet wide at the mouth, with clear water, and derives its supply from the north-eastern slopes of the Cassiar Range, to the north of French Creek. Blue River.

The "Lower Post," which is the furthest outwork of "civilization" or trade in this direction, is situated at the edge of a terrace forty "Lower Post."

feet in height on the left bank of the Liard, about half a mile above the mouth of the Dease. It is of a very unpretentious character, consisting of a few low log buildings, in the vicinity of which the woods have been entirely destroyed by fire.

The soil is poor near the post and the climate evidently unfavorable, but potatoes and turnips have been grown here in small patches.

Opening and closing of the river.

The Liard River is here said to open, as a rule, from the 1st to the 5th of May, though in 1887 this did not occur till the 18th of that month. In the autumn of 1886 it was frozen over on November 21st.

Mr. Egnell, in sole charge, received us on our arrival here with all distinction possible, displaying his Union Jack and firing a salute from his fowling piece. Before leaving we were indebted to him for many other courtesies, all of which are here gratefully acknowledged.

Geology of the Dease River.

Rocks west of granite range.

It would be impossible, without the expenditure of much time, to make anything like a complete geological section on the line of the Dease, in consequence of the infrequency of rock-exposures on the river itself and the distance and rough character of the bordering mountain-slopes. The main geological features are, however, sufficiently apparent. For about twelve miles below the lake the rocks composing the mountains seem to be referable to the same Palæozoic series, which has been described as occurring on Dease Lake, but the exposures examined appeared to be somewhat more highly altered, and in some cases to approach the character of crystalline schists. One bedded rock is probably a diabase, with somewhat lustrous division planes and kernels of epidote.

Granitic rocks of Cassiar Mountains.

Beyond the point above defined, at the first little lake, a granitic area is entered on, which may be regarded as constituting the axis of the Cassiar range, and which extends on the river to the mouth of the Cottonwood, constituting the entire Skree Range, and apparently also Anvil Mountain and the surrounding high mountain region, with a tranverse width of about thirteen miles. The granite here seen differs somewhat from that found on the Stikine in being more highly quartzose and occasionally garnetiferous. Mica is present in great abundance, and is in some specimens black, in others of characteristic pale, silvery colours. The existence of distinctly gneissic rocks was not ascertained, but the lithological character of the series resembles that of the lowest rocks of Shuswap Lake and other districts in the interior of British Columbia to the south, which have been provisionally referred to the Archæan.

East edge of granites.

The valley of Cottonwood Creek appears to coincide with the northeastern edge of the granites for a number of miles. The mountains to

the north of it, and extending eastward along the north side of the Dease, are evidently composed of stratified rocks, including important beds of limestone, the average dip being about N. 45° E. $<$ 30°. The northern spur of the mountain which terminates the Skree Range, opposite the mouth of Cottonwood Creek, shows the overlap of the stratified rocks upon the granites at a considerable height above the river. The mountains which run southward on both sides of Eagle River valley seem to be also granitic for the most part, though a greenish-grey felsite was collected on the river from the northern spur of the mountain to the east of the valley.

Little was ascertained respecting the rocks composing the mountains between Eagle River and Sylvester's Landing, but granite does not reappear in them. The range to the east of McDame Creek is largely composed of limestone, which, striking in a north-west and south-east direction, constitutes also the mountains on the south side of the Dease. The dip is generally westward, at varying angles, and the limestones are associated with reddish shales, and near the mouth of Rapid River were observed to be interbedded with dolomitic layers and calcareous schists. The total thickness of the strata brought to the surface along this part of the river must be very considerable. The lithological resemblance is close to the upper part of the Palæozoic section on the Bow Pass, including the Banff, Intermediate and Castle Mountain limestones of Mr. McConnell (Annual Report, 1886, part D). Limestones near the western or upper part of the river-section contain numerous obscure fossils, including brachiopods, corals, and apparently a sponge-like organism. I also satisfied myself of the occurrence of *Fusulina* on weathered surfaces, proving the Carboniferous age of the rocks in question. The pure limestones are usually grey and are not highly crystalline.

Rocks of McDame Creek Mountains.

Fusulina.

The mountains bordering the valley in the north-and-south part of its course, between the first and second great bends, appear to be composed throughout of similar rocks, though those on the west side are much better exposed than those on the east.

Eleven miles south of the second great bend, on the right bank of the river, is a low, rocky cliff, about fifteen feet above the water, capped by about ten feet of bedded white silts. The rocks are blackish, sandy shales, rather hard in some places, carbonaceous, and holding a little impure lignite. They are extremely irregular in dip, and are broken and jumbled up with a hard, grey quartzite, which is seen in places as the underlying rock, but is even then singularly shattered. The aspect of the shales is that of those of the Tertiary rocks, and it is possible that this locality represents an old shore-line, but more probable that the rocks form part of an ancient slide, or are upon the line of disturbance of a fault.

Confused exposure.

Possibly Triassic rocks.

At the second great bend there are a few exposures of a peculiar character, consisting of regularly bedded, dark, calcareous, flaggy argillites, alternating with grey, flaggy and massive limestones. Lithologically, these much resemble the Triassic of the West Coast, but no fossils could be found, though carefully sought for, and the evidence is quite too imperfect for the reference of the beds. The limestone is rather cherty, and gives out a fetid odor on being struck. The beds, as a whole, appear to form a synclinal.

Schists and slates of lower river.

From the second great bend to the mouth of the Dease, the underlying rocks consist of grey and black schists, the former generally calc-schists, and the latter more or less highly carbonaceous. They are interbedded with thin limestones, which often weather brown. The calc-schists are frequently glossy, and in some places form very thin, paper-like layers. Some of these rocks closely resemble those met with at the "Grand Rapid" on the Stikine p. 55 B. The general strike is north-west by south-east, but the direction and angle of dip is very varied, and the beds are frequently much disturbed and twisted, and traversed by veins of quartz and calcite. There are probably frequent repetitions of the same horizon, but the general arrangement may be synclinal, the dark shales and schists occupying the higher position, and being most abundant about the middle of this length of the river-section. Graptolites were found in the dark shales, particularly at a locality in a north bend of the river, eleven miles westward in a direct line from the mouth, and in appearance the whole series is much like that of the Cambrian calc-schists and Cambro-Silurian graptolite-shales of the Kicking Horse (Wapta) valley, west of the summit, on the line of the Canadian Pacific Railway.

Comparision with rocks to south.

The general aspect and association of the rocks to the east of the granite axis of the Cassiar Range closely resembles that of the Rocky Mountains about the 51st parallel, but differs in the large proportion of metamorphic materials of volcanic origin, which, from the *débris* brought down by streams, must be even more abundant than the exposures along the river would indicate. This difference is paralleled by the similar change which is met with on the 51st degree of latitude, in passing from the Rocky Mountains proper to the interior plateau of British Columbia.

Note on graptolites by Prof. Lapworth.

A small collection of graptolites, made at the point above indicated, has been submitted by Mr. J. F. Whiteaves to Prof. Charles Lapworth, of Mason College, Birmingham, who has kindly examined them, and furnishes the following note.—

"The graptolites collected by Dr. Dawson from the Dease River are identical with those examined by me from the rocks of the Kicking Horse Pass, some time last year. The species I notice in the Dease River collection are :—

Diplograptus euglyphus (Lapworth).
Climacograptus, comp. *antiquus* (Lapworth).
Cryptograptus tricornis (Carruthers).
Glossograptus ciliatus (Emmons).
Didymograptus, comp. *sagittarius* (Hall).
New form allied to *Cœnograptus*.

"The graptolite-bearing rocks are clearly of about middle Ordovician age. They contain forms which I would refer to the second or Black River Trenton period, *i.e.*, they are newer than the Point Levis series and older than the Hudson and Utica groups. The association of forms is such as we find in Britain and Western Europe, in the passage-beds between the Llandeilo and Caradoc limestones. The rocks in Canada and New York with which these Dease River beds may best be compared are the Marsouin beds of the St. Lawrence valley and the Norman's Kill beds of New York. The Dease River beds may, perhaps, be a little older than these. **Age of the fauna.**

"Mr. C. White described some graptolites from beds in the mountain region of the west, several years ago, which may belong to the same horizon as the Dease River zones, though they have a somewhat more recent aspect.

"The specific identification of the Dease River fossils I regard as provisional. While the species correspond broadly with those found in their eastern equivalents, they have certain peculiarities, which may, after further study or on the discovery of better or more perfect specimens, lead to their separation as distinct species or varieties.

"It is exceedingly interesting to find graptolites in a region so far removed from the Atlantic basin, and also to note that the typical association of Llandeilo-Bala genera and species is still retained practically unmodified."

Overlying these old rocks, in several places at about eight miles from the mouth of the Dease, are shaly clays and coarse, soft sandstones, associated with which a thin bed of lignite was observed. These are evidently Tertiary, and referable to the series afterwards found more extensively developed on the Liard, above the mouth of the Dease. Some very obscure remains of leaves were noticed, but none were collected. The beds dip at various angles, sometimes as high as 15°, and thus appear to have been, to some extent, affected by flexure subsequent to their deposition. It is not improbable that a considerable part of the higher plateau by which the river is here bordered on both sides, is composed of these newer rocks resting upon the upturned edges of the schists. **Tertiary strata.**

Drift deposits and terraces.

Some notes respecting the superficial geology of the Dease have already been given in connection with the general description of the river. It now only remains to add the following general observations.

The scarped banks along the upper part of the river, to the first great bend, generally show stratified sands and gravels only, all or most of which may be classed as old river-gravels. Between the first and second great bends, well-bedded, yellowish-white silts appear and are frequently exposed. The bedding is sometimes inclined and large boulders are occasionally enveloped in the silts, which are in some places seen to rest upon and pass into true boulder-clay, while they are generally capped by a variable thickness of stratified gravels. The silts, occasionally, rest directly upon the underlying rocks, and in other places have been removed, so that the gravels lie upon the boulder-clay or upon the underlying rocks. Below the second great bend, the silts still occur, but are not so important, being largely replaced by stratified sands and gravels. The approximate level of the highest observed beds of the silt formation may be stated at 2400 feet above the sea. The highest observed terraces on the sides of the mountains have an estimated elevation of about 4600 feet. Glaciated rock-surfaces were observed in a single locality, a few miles below the mouth of McDame Creek. They appeared to indicate a flow of ice eastward or down the valley, but were not sufficiently distinct to afford completely satisfactory evidence on this point.

Upper Liard River.

Proceedings at mouth of Dease

We arrived at the little post at the mouth of the Dease on June 23rd, in rain, which continued during the whole of the next day, rendering it impossible to obtain observations, which were here necessary. On the morning of the 25th, however, I secured a fair series of observations, and having completed such arrangements as we had to make before entering the entirely untravelled country to the north, left the same afternoon. Mr. McConnell was here detached with two men and a boat for the examination of the Lower Liard. We had arranged that a couple of local Indians should accompany each party for the purpose of assisting at portages and acting as guides, but those who went with us deserted after a few days, and we afterwards learned that Mr. McConnell's Indians behaved in the same manner.

Country near the confluence.

The country about the confluence of the Dease and Liard is low and uniform, rising from the rivers in a series of more or less regular terraces, to a plateau 400 feet or more above the water-level, or approximately 2500 feet above the sea. The extent of this low country is considerable.

The name of the Liard River, or Rivière aux Liards, refers to the abundance of the cottonwood or poplar, and was no doubt originally given to its lower portion. This name has been corrupted to "Deloire," in which form it is generally in use by the miners of the Cassiar country. It is often spoken of as the West Branch by traders on the Mackenzie, and has also been named the Mountain River, and sometimes the Great Current River or Courant-fort. It is called Too-ti' by the Indians of the country along its upper part, while, according to Petitot, the Indians nearer the Mackenzie name it Eréttchichié and Thèttadéssè.* The name Liard.

The Liard River, though one of the principal affluents of the great Mackenzie, has remained up to the present time practically unknown, or at least undescribed, though sketched from observations by officers of the Hudson Bay Company on Arrowsmith's maps, and copied from those on other maps. It has long been in use as an avenue of communication by the Company, but since the abandonment of the posts to the west of the Rocky Mountains, its upper part has been traversed only at rare intervals, by a few prospectors and miners from the Cassiar district. With Mr. McConnell's work on the lower part of the river, and the examination of its upper part here reported on, we now have a survey extending from Fort Simpson, at its mouth, to one of its furthest sources, in Finlayson Lake. Rivers hitherto unsurveyed.

This river and the Frances appear to have been ascended by McLeod, about 1834, as far as Simpson Lake, but in 1840 Mr. R. Campbell explored the same route to Frances and Finlayson Lakes (as subsequently mentioned in greater detail), and obtained the most accurate geographical information available to the present time. Sir J. Richardson, however, in his Arctic Searching Expedition (1851) gives such particulars of the Liard as he was able to gather from hearsay (Vol. I, p. 167; II, p. 203), and mentions having received in 1848, while on the Mackenzie, Honolulu papers of late date by this route from the Pacific. On the older maps, the Black or Turnagain River is designated as the main continuation of the Liard, but it is much smaller than the "North-west Branch" of these maps, to which the name is now applied. In the present report that part of this branch above the confluence of the Dease is, for purposes of description, distinguished as the Upper Liard. Previous knowledge of the Liard.

The Upper Liard, just above the mouth of the Dease and opposite the post previously referred to, is 840 feet in width, and on the 24th of June 1887 was found to have a maximum velocity of 4·54 miles per hour. The river was not cross-sectioned, but, with an estimated depth of six feet for one-third of its width, the quantity of water car- Size of the river.

* Bulletin de la Société de Géographie, vol. x, p. 152.

ried would amount to about 19,000 cubic feet per second.* This may be regarded as a rough approximation for the mean stage of the river, which, when in flood, probably carries at least double this volume of water. It is a turbid yellowish stream, and contrasts in this respect with the clearer water of the Dease, which river, at its confluence with the Liard, probably carries about half the volume of water above assigned to the latter.

Character of Liard and Frances Rivers. From the mouth of the Dease River to the confluence of the Frances River, the general bearing of the Liard is nearly due north-west, the distance, in a straight line, being thirty-three miles, or following the course of the river, forty-five miles. The Frances River, which was followed from the last-named point, disregarding its minor flexures, has a nearly direct north-and-south course. A straight line drawn from the mouth of the Dease to the lower end of Frances Lake is ninety-four miles in length, but the distance between these points, following the flexures of the river, is one hundred and thirty-five miles. Almost every foot of this distance had to be made by poling or tracking against the rapid stream, and as our boats were heavily laden and not as well suited in build as they might have been for the work, the ascent to Frances Lake occupied twelve days, or an average distance of about eleven miles a day only. As the river was entirely unknown to us and some time was unavoidably lost in reconnoitering rapids and selecting portages, besides the delays incident to surveying work and geological examination, I believe, that with a good boat and crew, the ascent to the lake might be made in about half the above time at the same stage of water. In very high water it would be extremely difficult to pass through some parts of the cañons, while at exceptionally low stages of water, when it would be possible to substitute tracking for poling in many places, the distance might be accomplished in even less time.

Lower Cañon. Six miles above the mouth of the Dease, by the course of the river, the entrance of the *Lower Cañon* is reached. The full height of the plateau through which the river here cuts, is about 500 feet, but banks of this height seldom abut directly on the river. The upper parts of these banks are composed of stratified sands and gravels, but the lower part of the gorge is cut through shaly and slaty rocks, which are perpendicular or form very steep slopes, averaging about a hundred feet in height. The cañon is three miles in length, and at high water it is said to be necessary to portage the whole of this distance. We were obliged to lighten the boats and make four small portages over rocky points, where the current was dangerously swift. The latitude,

* Estimated by approximate formula, Trautwine's Engineers' Pocket-book, 1882, p. 562. The depth above assigned to the river is probably too small.

observed at noon near the middle of the cañon, was 60° 01′ 06″. Finding that we were so near the northern boundary of British Columbia (Lat. 60°), we made a small cairn of stones on a prominent rocky point, in the centre of which a post was erected, on which the latitude was marked. The 60th parallel may be said to coincide almost exactly with the lower end of the cañon.

Rocks of Lower Cañon.

The rocks seen in the Lower Cañon resemble those described as characterizing the lower part of the Dease River and Dease Lake, being shales or schists, which in some places show slaty structure. They are generally dark with plumbaginous matter. With these are associated grey, somewhat glossy schists, and calcareous schists which pass in some places into pretty pure, thin-bedded limestones. Quartzites are also present, and all the rocks are occasionally locally silicified. The whole series is much disturbed and contorted, and is broken by innumerable small, irregular seams and veins of quartz and calcite, with some dolomite, though no well-marked or important lodes were seen. Galena is reported to have been found in some of the veins, and to have yielded a small return in silver on assay.

River from Cañon to Frances.

Above the Lower Cañon the river continues swift, the current averaging about four miles an hour, and much exceeding this rate in many reaches. It is wide and shallow, and in places becomes a complete maze of islands and gravelly, half-submerged bars, causing much difficulty and loss of time from the frequent necessity of crossing from one to another of these to avoid under-cut banks, with water too deep for poling. Our actual travelling time from the Dease to the mouth of the Frances, deducting all stoppages, was thirty-eight hours and a-quarter.

The river-valley averages about two miles in width, and is cut out to a depth of 300 feet or more in the plateau, which occasionally rises directly from the river-bank to its full height, though the stream is usually bordered by terraces of inferior height, alternating with low flats, which occupy the concave sides of the bends. The higher ground is generally wooded with spruce, while the black pine (*Pinus Murrayana*) is abundant on dry terraces, and groves of cottonwood of medium size often occur on the flats. Aspen poplar is not uncommon, and a few birch and larch trees were seen. Little of the timber is of useful size or quality. The dry bars and gravelly flats were, when we passed, gay with *Epilobium latifolium*, *Oxytropis campestris*, *O. Lamberti* and *Dryas Drummondii*, and the wild roses were rapidly coming into flower.

Rancheria River.

About midway between the Dease and Frances a small river enters from the south-westward, which has been called the Rancheria River, but of which I do not know the native name. It appears to debouch by several mouths when in flood, and apparently rises in the eastern

slopes of the Cassiar Range. A few miles above this, on the opposite side of the river, a small lake, reputed to be well stocked with fish, is reported. About seven miles below the mouth of the Frances, on the south west bank, is an old Indian camping place, which is said to be frequented at certain seasons by the Tahl-tan Indians for purposes of trade. It is reached by these people by some overland route which crosses the Cassiar Mountains to the north of the Dease River.

Confluence of Liard and Frances.

The Liard is full of islands at its confluence with the Frances, rendering it difficult to estimate the relative importance of the two streams, but they appeared to carry about an equal quantity of water. The Liard is, however, evidently more subject to freshets; Frances Lake doubtless serving to regulate the flow of the Frances River, the water of which is a clear, pale, amber color, and does not thoroughly mingle with the yellowish, turbid water of the Liard for some miles. Above the confluence, the Liard valley is seen to trend off in a south-westerly direction for ten miles or more, after which it again turns to the north-westward, and, from the scanty information available concerning it, seems to flow along the eastern side of the northern continuation of the Cassiar Range, from which it receives most of its water.

Sayyea Creek.

On comparing the statements of the few miners I have seen who have ascended this river, it appears that Sayyea Creek, which is an inconsiderable stream, flows in from the west about fifty-five miles above the mouth of the Frances. Good gold "prospects" were found on this creek in 1875, a number of pieces worth ten dollars having been obtained, but little work has ever been done. Of a party of miners who spent the winter of 1874-75 in its vicinity four died of scurvy. Of the other tributaries of the Liard, which must be numerous, I have been unable to ascertain anything authentic.

Names of Liard and Frances Rivers.

Respecting the names of the Liard and Frances rivers, it should be mentioned that Campbell called that which is now known as the Liard the "Bell River," after Mr. J. Bell, of the Hudson Bay Company. Under this designation it appears on Arrowsmith's map of 1854, the name Liard being applied to the branch now known as the Frances. Usage has, however, changed the first nomenclature, and it is undesirable to attempt to revert to the original names, as, irrespective of the question of relative size, the physical characteristics of the Liard below the confluence are undoubtedly continued on the west rather than on the east branch above that point. The Indian name of the Frances is identical with that of the Dease, being Too-tsho-tooa', or "Big Lake River."

Rocks above the Cañon.

Rocks like those of the Lower Cañon are seen at intervals for about two miles above its head, beyond which, for about three miles, stratified gravels and sands only appear in the banks. Six miles from the cañon

Tertiary clays of whitish and grey colours, and associated with impure lignite, are first met with, and these continue to appear here and there along the river as far as the Frances. The thickest bed of lignite observed was about three feet, four miles below the Frances. The lignite is generally impure and often very distinctly laminated. It resembles in character the lignites of the Miocene of British Columbia, and the associated clays and soft shales are similar in character to those of that formation. Numerous boulders of basalt are found along this part of the river, and the basalt was observed to form a mural cliff, at a height of about 300 feet above the river, at a place just below the mouth of the Rancheria River. This rock evidently overlies the lignite-bearing beds. The shaly clays and lignites show evidence of considerable disturbance, and dip in some places at rather high angles. This may be due to the action of old land-slides along the banks of the river, but appears to be rather too constant to be satisfactorily accounted for in this way. Lignite. Basalt.

Near the mouth of the Frances the white silts again become a prominent feature, though scarcely seen lower down the river. They overlie the Tertiary rocks and hold concretions of various forms here and there. They are capped by the usual stratified sands and gravels, which generally have a yellowish or rusty colour. White silts.

The gravel bars and the shores of this part of the Liard are almost half composed of rolled quartz pebbles, which have evidently been derived from veins traversing relatively soft schistose rocks like those of the cañon. The great quantity of such vein material present in this district may be regarded as a favorable indication in respect to mineral development. Some small bars have paid to work along this part of the river, and gold is also found in some layers of the gravel deposit which overlies the older rocks along the cañon and above it, where "wages" at $4 a day can be made. The amount of cover which it soon becomes necessary to remove in following the paying layers, has prevented extensive mining, but probably these gravels might be advantageously worked as a whole, by sluicing or by the hydraulic method. Gold.

No general view of the country can be obtained from the river, owing to woods and the depth of the valley, but from high points of banks above the river, near the Frances, a large area may be overlooked. Thus seen, the country is found to be a wide, rolling plateau, with an average elevation of about 500 feet above the river, or say 2700 feet above the sea. It rises here and there, however, in broad, rounded swells, or flat-topped higher plateaux with steep edges, and a considerable part of this higher ground is at an elevation of about 1000 feet above the river. The plateau is everywhere wooded, except General appearance of the country.

where intersected by grassy or mossy swamps of small area. There is a large triangular region of country of this kind between the Upper Liard and Dease, which is bounded to the westward by the front of the Cassiar Range, the sharp, rocky peaks of which carry a considerable quantity of snow and run along the horizon line for many miles, but which, with the exception of a few outlying summits, is at a minimum distance of about twenty-five miles from the mouth of the Frances. The same low country runs in a north-north-westward direction, without apparent limit, forming the upper part of the Liard valley. To the eastward it is bounded, at a distance of about ten miles, by a comparatively low range of rounded mountains and hills, which, from the Indian name of one of its salient points to the northward, may be called the *Tses-ī-uh Range.* The part of this range nearest to the confluence of the Frances and Liard has an elevation estimated at about 3500 feet above the sea. Like other main features of the country, it runs in a north-north-west by south-south-east direction, but dies out completely before reaching the Upper Liard River, which, if continued, it would do at the Lower Cañon. It is probable, indeed, that the cañon is produced by the river cutting across the extension of the same ridge of rocks which produces these hills. The general uniformity of the plateau appears to be largely due to the Tertiary rocks, which doubtless underlie almost its entire area. The appearance of some of the flat-topped hills above alluded to is suggestive of the occurrence of sheets of basalt overlying the softer rocks. The forms of the Tses-ī-uh Mountains show that they are not thus composed, but Tertiary rocks may again occur beyond them, in the valley of the McPherson or Highland River, which is not far off.

Cassiar Range.

Mountains to the east.

Tertiary plateau.

FRANCES RIVER.

Mouth of Frances to Middle Cañon.

The general direction of the Frances, for nine miles from its mouth, is north-north-west. It then bends to the north-eastward, and in four miles the lower end of the Middle Cañon is reached. For the first few miles above its mouth the Frances is extremely tortuous, so much so that the distance following the actual course of the river to the foot of the cañon is twenty-two miles. This river, like the Liard, was at a medium stage near the end of June, 1887. Marks along the banks showed that it had been about six feet higher in the spring, and that it had since been falling. Its average width in this part is about 600 feet, and the rate of the current, at the medium stage above referred to, about four miles and a-half an hour.

Terrace.

The highest land immediately bordering on this part of the river is a terrace at a height of about 150 feet above it, the surface of which is

in some places composed of almost pure sand, upon which open woods of *Pinus Murrayana* grow. Larch was observed to be moderately abundant in damp, shady localities and the banks were in some places diversified with flowers, of which *Potentilla fruticosa* and *Primula mistassinica* were specially noted.

Exposures in the banks. Numerous small exposures of Tertiary shales and clays, of grey, blackish and yellowish tints, occur along this part of the river. Lignite is strewn in great quantities over some of the bars, and though thin seams occur in places in the banks, it is probable that thicker ones exist in the bed of the river. The lignite often holds drops of fossil resin or amber. The Tertiary rocks are very generally covered by silts, like those already several times alluded to. In a bank near the mouth of the river, which gives a complete section from the top of the terrace above described, the lowest deposit consists of roughly stratified gravel and clay, with some glaciated boulders. This is followed by the silts, which are again in turn covered by stratified sands and gravels. The lowest deposit probably represents the boulder-clay, and resembles that of the Upper Pelly River, subsequently described.

Quartz is not so abundant a constituent of the gravel of the river-bars on this part of the Frances as it is on the Liard below, and no basalt blocks or boulders were observed here.

Middle Cañon. The *Middle Cañon*, as it may be called for the purpose of distinguishing it, is about three miles in length, the river being hemmed in by broken, rocky cliffs of 200 to 300 feet in height for the greater part of this distance. We took our boats up along the south-east bank, making four short portages of part of the stuff, and two of both boats and load, across narrow, rocky points. One portage of greater length, on the opposite bank, would overcome all the really bad water, but the banks on that side are rougher, and the whole force of the current sets against the cliff in one place in a dangerous manner. The total fall in the cañon is estimated at about thirty feet.

This cañon is evidently produced by the southern extremity of a second range of mountains parallel to the Tses-ī-uh Mountains, but to the west of that range. This southern spur, though submerged in the Tertiary and drift materials by which the general surface of the country is covered, nevertheless presents a rocky barrier to the passage of the river, and in this place constitutes the eastern margin of the Tertiary basin, no beds referable to which are seen further up the Frances. The range of mountains here referred to may, for convenience, be named the *Simpson Mountains*.

Rocks of the Cañon. The exposures in the lower part of this cañon show limestones, some of which are moderately pure, but others are nearly half composed of small, more or less rounded fragments of siliceous and schistose rocks.

These weather to rough surfaces, and have a very peculiar aspect, as an intense pressure appears to have flattened the contained fragments parallel to a single direction. These limestones are associated with several varieties of calc-schists, with hard, greyish-blue, cherty quartzite, with schistose breccia, which appears to have been originally of volcanic origin, and with some pretty evident volcanic agglomerate. Further up, the rocks have been completely shattered and variously changed in appearance by solfataric or some similar action, some parts being bleached, while others are reddened by the deposition of iron, forming cliffs of a remarkably varied appearance. The upper gate of the cañon is composed of white cliffs of marble and quartzite, all much shattered. The marble and limestones are in places associated with red shales, resembling those found in a similar association on the Dease, near the eastern edge of the Cassiar Range, and the rocks of this part of the section are probably like those, of Carboniferous age. Specimens of *Fusulina*, with polyzoa, etc., are found in some of the limestones on microscopical examination. Stratigraphically, the rocks seen in the sections are all much confused and broken, and the angles of dip are very varied, though the strike may, in a general way, be given as north-north-west. The Simpson Mountains which are upon this line of strike are doubtless composed of rocks of the same character.

Fusulina.

Beginning of mountainous country.

Above the Middle Cañon, the general course of the river is again north-north-westward for about twelve miles. It is here usually bordered by quite low land on both sides, and the valley between the southern end of the Simpson Mountains and northern part of the Tses-ī-uh Range is about three miles in width. The wide, uniform plateau country is now, however, left behind, and we enter a generally mountainous region, though the highest summits in this immediate vicinity scarcely exceed 3000 feet above the river. Their forms are rather rounded and flowing, and the slopes of those on the east bank are nearly bare of trees, while the opposite range is generally wooded, but evidently with trees of small growth. The river itself is wide and deep, with a rather slack current. A single exposure only, composed of grey-green, silvery schist, was seen along this part of the river.

Simpson Lake.

Near the end of this reach of the river, two considerable streams enter on the west side, and on one or other of these, at no great distance from the river, Simpson Lake of McLeod and Campbell is situated. As the Indians who had accompanied us from the mouth of the Dease had deserted before we reached this place, I was unable to ascertain any definite particulars respecting the lake, though it is reported to be a good one for fish. The position of Simpson Lake, as indicated by broken lines on the map, must therefore be regarded as quite uncertain. The same doubt applies to the Indian names of

several rivers tributary to the Frances above this point, for although one of the local Indians had made for us, upon a sheet of canvas used as a boat cover, an elaborate charcoal drawing of the whole system, it proved to be extremely difficult to recognize the features represented. The Indian map, such as it is, serves to show that the streams tributary to the Frances River rise in a number of lakes, some of which are reported to be of considerable size, and offer a most attractive field for further exploration. We were told, however, that none of the lakes in this region are equal in size to Frances Lake, for which we were heading, a statement borne out by the circumstance that both this and Dease Lake are known in their respective districts as Too-tsho, or "big lake," while the Frances and Dease rivers are, as already mentioned, both similarly named Too-tsho-tooa', or "big lake river." Tributaries of the Frances.

From the point just noted, the direction of the river changes to north-east, cutting across the direction of the Tses-ī-uh range, which terminates at the edge of the river in low, wooded hills. The current is moderately swift throughout, and in one place the river is bordered on both sides by low, rocky banks, but no rapids are met with. This we named the *False Cañon*. One or possibly two streams enter from a valley which runs to the east of the range just mentioned, but they are not of large size. Greyish-green, quartzose mica-schist and greenish silvery schists were seen in one or two places, and in the low rocky banks above alluded to, blackish argillites and grey quartzites, of a less altered appearance than usual, but from which no fossils were obtained, occur. False Cañon.

From the end of this reach the general course of the stream again becomes north-north-west for about thirteen miles, running for the greater part of this distance parallel to, and a mile or two miles from the base of a mountain range, which comes in to the east of the Tses-ī-uh Range. The country to the west of the river is here either flat or characterized merely by low, rounded and wooded hills for many miles back, the eye ranging across this country to the continuation of the Simpson Mountains, which, with generally rounded forms and no striking summits, reach elevations of 6000 to 6500 feet. These mountains do not form a strictly connected range, but appear rather as a series of mountainous areas, separated by wide, low passes. The Indian map above referred to shows three or four lakes in this region, supplying a stream named *Too-tshī-too-a*, which flows into the Frances, reaching it probably just above the Upper Cañon. None of these lakes were visible from any point reached by us. On the opposite side, one stream of considerable size joins the Frances. This is supposed to be the *Agā-zī-za* of the Indians, and, if so, is represented as rising in a chain of small lakes, some of which drain in an easterly direction River above False Cañon. Lakes.

to the Macpherson (*Eg-is-e-too'-a*) River. The valley occupied by these lakes is a travelled route employed by the Indians.

Granitic rocks. The current is swifter in the upper than in the lower portion of this part of the Frances, and there are numerous islands in the river, but no rock-exposures occur. The mountains to the east of the river are high, but have blunt, rounded forms. Much bare rock shows in their sides, but there is no appearance of stratification, and this, with their form and color, and the great abundance of that material found in the streams in this vicinity, renders it nearly certain that they are composed of granite.

Character of the mountains. The mountains so far met with in the vicinity of the Frances form rather isolated ranges or masses, which rise somewhat abruptly from generally low country, or are separated by wide valleys, the appearance being that of a mountain system partly buried in later deposits; though no Tertiary rocks, either in place or as loose fragments, are met with above the Middle Cañon. The granitic mountains last referred to form an outlying spur or buttress of the most important range of the district, the axis of which is here about twelve miles east of the river. This it is proposed to designate the *Too-tsho Range.** The southernmost high summit observed was named, from its form, *Tent Peak*. It is situated in latitude 60° 52′ 45″, and has an altitude of 7860 feet above the sea.

Upper Cañon. The river next makes an abrupt turn to the west for four miles, a mile and a-quarter of this distance being occupied by a series of rapids, which are rocky and rather strong, and have a total fall of about thirty feet. The banks rise steeply from the river to heights of 100 to 200 feet, though the rocky cliffs along the water are of inconsiderable height, scarcely anywhere exceeding fifty feet. This place may be named the *Upper Cañon*, and is the last serious impediment to the navigation of the river. We found it necessary to make several short portages, but with a large boat and at a good stage of the river, it is probable that one portage of about 1000 feet in length, on the south bank, would overcome all the dangerous water, while the boat might be tracked up light. A stream, with moderate current at the mouth and about fifty feet wide, enters a short distance below the cañon, coming from the mountains to the north of Tent Peak. The rocks of the Upper Cañon comprise black, glossy calc-schists, black quartzite or chert, bluish limestone, and some green-grey, silvery schist. Similar rocks are seen again a couple of miles up the river, above the cañon, where a rapid occurs. The dips are all low, and so far as observed, uniformly in a northerly direction. Some of the schists are highly

Rocks of Upper Cañon.

* From the native name of Frances Lake. I was unable to ascertain the Indian name of this range, if indeed it has any such.

silicified by action subsequent to their deposition, and parts of all the rocks, including the limestone, are reticulated with narrow quartz seams. Near the upper part of the cañon some hard conglomerates occur, holding schistose fragments, as well as limestone pebbles, in which crinoidal joints are observable. It is not improbable that two unconformable series of rocks occur here, but I was unable to find means of distinguishing them in the sections.*

From the Upper Cañon to Frances Lake, a distance of twenty-one miles and a-half in a straight line, the river maintains a northerly direction with considerable uniformity. It is deep, with a moderate current, for about eight miles, or to *Moose Island*, above which for ten miles the current is again swift, averaging from four and a-half miles to five miles an hour. It again becomes slack for a short distance below the lake. Some portions of this part of the river are much broken up by islands and gravel bars. The river-valley averages about ten miles in width, extending to the slopes of the Too-tsho Range on the east, and being bounded to the westward by a series of rounded mountains, which diverge to the northward from the direction of the first-mentioned range, and run to the west of Frances Lake. These I propose to name the *Campbell Mountains*, for Mr. R. Campbell, whose initial exploratary trip through this country for the Hudson Bay Company is elsewhere referred to at length. Upper Cañon to Frances Lake.

The valley is partly occupied by terrace-flats, and partly by wooded hills or ridges with rounded or flowing forms but which rise in some places to heights of several hundred feet. The Too-tsho Range is here very compact and regular, and runs due north-and-south, the higher summits reaching 6500 to 7000 feet, and carrying some snow, though nothing like true glacier-ice was anywhere seen. The lower slopes of the range toward the river-valley are singularly uniform and light. Two or three streams of some size enter the river from the eastward in this part of its course. All that could be gathered respecting these is shown on the map. The furthest north was named Tyer's River by Campbell, and is known to the Indians as *Pas-ka'*. The exact position of its mouth was not definitely ascertained. Too-tsho Range

On approaching the lake, low ridges and irregular mounds begin to appear in the vicinity of the river, projecting through the lower terraces and suggesting the existence of morainic deposits. Large boulders also become abundant in the river-bed. No rock-exposures whatever were seen along this part of the river. Morainic ridges.

Our actual working time on Frances River, from its mouth to the lake, was sixty-seven hours and a-half. The difference of level between Travelling time on Frances River.

* If so, the rocks here noted may represent the Cretaceous to which they are lithologically similar.

Frances Lake and the mouth of the Dease is 477 feet. By assigning ninety feet of this to the fall in the three cañons, and dividing the remainder by the total length of the river (less the aggregate length of the cañons), we obtain an average rate of descent very slightly exceeding three feet to the mile, which is about what might be anticipated from the current met with in the river, as compared to that of other streams in the district.

Frances Lake and Vicinity.

Frances Lake. The elevation of Frances Lake above the sea, as determined by a series of barometer observations extending from the 8th to the 16th of July, is 2577 feet. Three miles from its lower end, the lake bifurcates, forming two approximately equal and nearly parallel arms, with lengths of about thirty miles. The two arms are about eight miles apart, and are separated by a group of low, rounded mountains, the culminating point of which, with an elevation of 5230 feet, was named Simpson's Tower by Campbell, the lake itself receiving its name at the same time in honour of Lady Simpson. The eastern side of its east arm is bordered by the Too-tsho Range or hills attached to it, while the country to the west of the west arm rises more gradually to the bases of the Campbell Mountains, some miles distant. Though so far referred to as a single lake, this body of water is in reality entitled to be considered as a group of lakes. The upper end of the west arm, with a length of five miles and a-half, is separated from the main portion of the same arm by a river-like constriction over a mile in length, while the east arm is entered by a narrow and inconspicuous opening with a strong current flowing out, and the real extent of this arm is seen only after passing, for about seven miles, through a series of irregular basins and small lake-like expansions connected by narrows, in which a very perceptible current is found. It appears best, however, to retain Campbell's original name for the whole body of water, rather than to multiply names for which there is no immediate call.

Character of its valley. Except in its bifid form, for which there are several parallels, and which results merely from the convergence of two valleys of similar character, Frances Lake closely resembles a large number of lakes in the mountainous regions of British Columbia, and has the long narrow parallel-sided outline characteristic of lakes which occupy old valley-excavations, the drainage of which has become interrupted in various ways. In this case, as in a number of others, there can be little doubt, that the lake is held in by morainic accumulations. The great number of boulders near its outlet has already been referred to, and the lumpy, irregular mounds and ridges composed of detrital matter, on the lower

seven miles of the east arm, as well as on the corresponding portion of the west arm, appear without doubt to represent moraines in a more or less degraded condition. The average width of the upper portions of both arms, above these interruptions, is pretty uniformly maintained at about a mile and a-half, such irregularities as occur being produced by gravelly and sandy flats a few feet above the water-level, which have been formed at the mouths of entering streams. The extent and uniformity of these points, is such as to show that the lake must have remained, during a long period, approximately at its present level. The most important of these low points is that which separates the upper part of the west arm, already referred to, and is due to the Finlayson River.* The next is produced by a second stream which enters on the same side five miles and a-half below. This stream is somewhat smaller than the Finlayson, and is known to the Indians as the *Il-es-too'-a*.

Except along the upper part of the eastern side of the east arm, the mountains do not slope down abruptly to the shores of the lake. Elsewhere, the lake is almost continuously bordered by a terrace-like plateau, which is widest to the west, and has an average elevation of about 300 feet. This resembles the low country found about Dease Lake, though even more uniform and less sloping in character, and is not far from the same actual elevation above the sea in both cases. The streams entering the lake generally cut down through the edges of this plateau-like margin, in deep narrow gorges, the sections in which show that it is composed largely of rock, though levelled up to some extent by the addition of superficial gravelly deposits. This fact appears to indicate that the lake or the drainage level of the country was maintained for a very prolonged period at or near the height of this plateau before the base-level of erosion was so lowered as to permit of the excavation of the lower valleys in which the lake now lies. There is, in addition to this, a second lower terrace, not so well marked, and not often of great width, at an elevation of ninety feet above the lake. This is seen on both arms, and is composed of gravel and other detrital deposits. It is specially conspicuous about the mouths of the entering streams, and marks a later stage at which the water of the lake stood, for a relatively short time, subsequent to the glacial period.

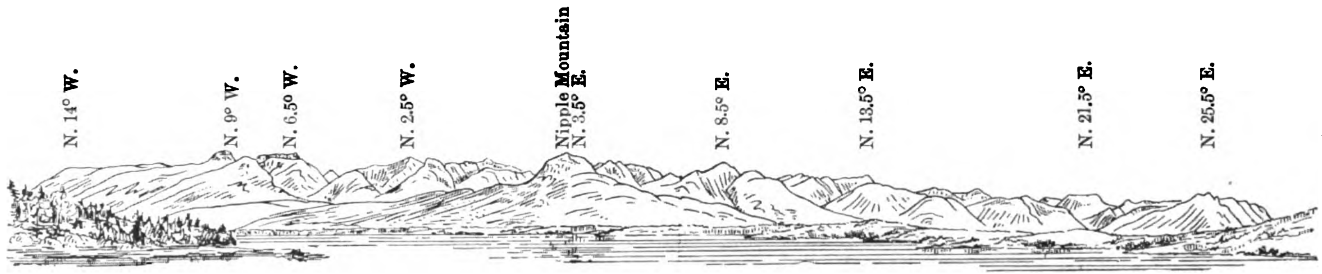
Country surrounding the lake.

Origin of terraces.

Few lakes which I have seen surpass Frances Lake in natural beauty, and the scenery of the east arm, bordered on the east by the rugged masses of the Too-tsho Range, is singularly striking. The mountains of this range are very varied in form, and a number of points surpass 7000 feet in height, while one was found to attain an elevation of about

Picturesque scenery.

* So named by Campbell after Chief Factor Duncan Finlayson, afterwards a member of the H. B. Co. Board of Directors.



G. M. D. delt.

FIG. 6. OUTLINE SKETCH OF PART OF THE TOO-TSHO RANGE, FROM WEST SIDE OF FRANCES LAKE, AT ITS OUTLET.

(The figures placed above the various summits are true bearings.)

9000 feet. This is named *Mount Logan*, for the late Sir W. E. Logan. Heavy masses of snow rest in some of the valleys, but no true glaciers are produced, a fact indicating a comparatively small snow-fall. The broken outlines of this range contrast strongly with the rounded forms of the mountains to the west of the west arm, with which Simpson's Tower and associated hills, separating the two arms, also conform.

The west arm terminates in a nearly circular basin about a quarter of a mile in diameter, at one side of which a fair-sized river, easily navigable for boats, flows in. The east arm was not followed to its head, though its termination in low land was seen. Here also, according to Campbell's sketch, a considerable river, which he has named Thomas River, enters. **Terminations of the lake.**

The two valleys, the lower parts of which are occupied by the east and west arms of the lake, run on far beyond the heads of these arms. Each of the rivers flowing in these valleys (according to the Indian sketch already referred to) eventually bifurcates, and all four streams thus formed rise in lakes. The river flowing into the head of the west arm is named *Yus-sez'-uh*, and the lake on its western branch is known as *Us-tas'-a-tsho*. No name was obtained for the lake on its eastern branch, which is evidently, however, Macpherson Lake of Campbell. **Upper parts of tributary valleys.**

Henry Thibert, who made a prospecting expedition up the west arm of Frances Lake and far up the river in question, some years ago, has kindly supplied me with some notes on it. He estimated the river, from the head of the arm to Macpherson Lake, to be about thirty-six miles in length, while Macpherson Lake is ten miles long. The first distance was, however, intended to include the windings of the stream. He did not visit Us-tas'-a-tsho, which, however, from the termination tsho (=big) is probably large. Us-tas is the name of the mythical culture-hero of the Tinné. The Indian name of Thomas River is *Too-tlas'*, the lake in which its eastern branch rises being named *Tus-tles-to*, the source of its western branch *Tïl-ê-i-tsho*. These lakes and connecting rivers are indicated by broken lines on the map, from Thibert's account and the Indian sketch of the country, combined with the observed positions of several of the mountain ranges.

The mountains to the north in which these rivers rise, were too distant to enable us to fix them with any great accuracy from points occupied by us on Frances Lake, but the whole country in that direction, from such views as were obtained of it, appeared to be rugged and high. It was with great regret that we were obliged to abandon the idea of exploring these rivers further, but the summer was already so far advanced, that this was impracticable, in view of the journey still before us. **Mountains to the north.**

The water of Frances Lake is clear and of a pale, brownish tint, and the lake is evidently very deep in its upper portions, though rather

Rock exposures shallow where encumbered by the morainic accumulations already alluded to. Rock exposures are, as a rule, quite unfrequent along its shores, which are generally composed of gravel and sand. At the time of our visit it was about six feet below its extreme high-water level, and it does not appear to be subject to very great fluctuations. Drift-wood is very abundant along some parts of the shores, particularly in the west arm, and it is probable that much of this is brought down by the river entering at the head of this arm. Lake-trout, white-fish, pike and suckers were found in the lake in considerable abundance.

Old Hudson Bay post. The site of the old Hudson Bay post is just above the narrow entrance to the east arm, on the edge of the bank, facing westward. Though Mr. Campbell had given me an accurate description of its position, it was so completely overgrown with bushes and small trees, that it was discovered with difficulty. The outline of the old stockade, with bastions at the corners, is still visible, though all traces of the structure itself has disappeared. This post has been abandoned since 1851.

Forest. All the lower country about Frances Lake is well wooded, and the mountains are also covered with forest, save where exceptionally steep and rocky, to a height of at least 1500 feet above the lake, while trees of smaller growth extend in the valleys considerably higher. The most abundant tree, here as elsewhere in the region, is the white spruce (*Picea alba*). It frequently attains a diameter of two feet, growing tall and straight on low ground and in sheltered places. The black spruce (*Picea nigra*) is also abundant. The larch (*Larix Americana*) is characteristic of damp, cool, northern slopes, and birch (*Betula papyrifera*) is moderately abundant, though not large. The shores, and particularly the delta-flats at the mouths of streams, are characterized by groves of cottonwood (probably all referable here to *Populus balsamifera*) and black pine (*Pinus Murrayana*).

Burnt country. Large tracts of country have been burnt over, many years ago, and extensive recent fires have swept the western side of the upper part of the east arm. Where a second growth has had time to spring up, it consists generally of mixed spruce, aspen and birch. Alders are common, but scarcely arboreal, along the borders of the lake. In the middle of July thickets of wild roses were seen in many places in full bloom.

General aspect of country. Taken as a whole, the growth of the forest and appearance of the country is remarkably pleasing, considering the high and northern position of the lake. The only characteristic difference of the woods here, as compared with those of the interior of British Columbia about the 54th parallel, is the great abundance and depth of the soft, mossy and lichenous floor which is everywhere found in them. The trees are also often well bearded with moss, affording evidence of a continuously

moist atmosphere, to be accounted for by the almost daily occurrence of light showers and the great prevalence of clouded skies, which was found throughout this part of the country. As before noted, however, the snow-fall cannot be great, nor is there any indication that the total annual precipitation is very considerable.

Geology of shores.

The infrequency of rock exposures along the shores rendered it difficult to obtain any connected idea of the geology of the lake, both arms of which appear, however, to occupy valleys excavated along the strike of comparatively soft black and greyish glossy schists, which are often calcareous and frequently interbedded with bluish limestone. In lithological appearance these rocks resemble those of the Cambro-Silurian, in which graptolites were found on Dease River, though no fossils were obtained here. The strike is parallel, so far as observed, to the directions of the arms, the prevailing dips being westward on the west arm, eastward on the east arm. The character of the harder and doubtless older rocks which occupy the centre of the anticlinal thus formed and compose Simpson's Tower and connected hills, was not ascertained.

Quartz veins numerous.

The high rugged central parts of the Too-tsho Range are composed largely or entirely of grey granite, pebbles and boulders of which are everywhere abundant, and particularly so along the beaches of the east arm. There is, too, a notable abundance of quartz along all the beaches of the lake, this material being derived from innumerable veins which traverse the schists in all directions, though most often found parallel to the bedding-planes, and generally assuming forms more or less lenticular. The largest of these are often several feet in width, and those seen in the cañon of the Finlayson, near its mouth, are of workable dimensions, if only moderately rich in gold. Specimens of quartz veins, containing some iron and copper pyrites, from the east side of the east arm about midway up it, were found to contain traces of gold on assay by Mr. Hoffmann.

Prospects for gold mining.

In general appearance the rocks of Frances Lake very closely resemble those from which the rich placer gold deposits of Dease Lake are derived, and they are probably of about the same age. Several "colours" to the pan were obtained from surface gravel at the mouth of Finlayson River, which struck me as specially promising in aspect and there seems to be no reason why some of the streams flowing across the schistose rocks into the lake or in its vicinity should not prove to be richly auriferous. This entire district well deserves careful prospecting. After my return to the coast, in the autumn, I ascertained from Charles Monroe that he and some other miners had actually done some prospecting in the vicinity of the lake at the time when the Cassiar mines were yielding largely, and the more enter-

prising men were scouring the country in search of new fields. He reached the lake from Cassiar by the same route we had followed. On comparing notes we found that he had worked for a short time at the mouth of the Finlayson, where he found the gravel to pay at the rate of from $8 to $9 a day.

Country between Frances Lake and Pelly River.

Proceedings at Frances Lake. We reached Frances Lake an the morning of the 8th of July, and had we been able to find any local Indians to serve as guides and assist in carrying over our stuff, we should have proceeded at once to the best point for that purpose and continued our journey overland toward the Pelly. As it was, it became our first object to endeavour to find the trail used many years previously by the Hudson Bay Company, of which a general description had been furnished by Mr. Campbell. This necessitated a careful examination of the west shore of the west arm to its head, which enabled us to identify, with tolerable certainty, the stream which Campbell had named the Finlayson. It was supposed that the Indians might have employed the same route in the periodical journeys which they were known to make from the Pelly down the Frances to the little trading post at the mouth of the Dease; but though the remains of an old log *câche* of the Hudson Bay Company were eventually found, together with the nails and iron work of a large boat which had evidently been burnt on the beach near it, no sign of a trail could be discovered. It thus appeared very doubtful whether we should be able to make our way across to the Pelly, with sufficient provisions and the necessary instruments for the continuation of our survey in the Yukon basin.

Search for Indians. In order to exhaust the possibility of obtaining further assistance before making the attempt, I made a light trip in one of our boats round into the east arm, which was known to exist from Campbell's report, but the narrow entrance to which had not even been observed on our way up the lake. This also enabled me to sketch the east arm, but no Indians were found; in fact, we discovered traces of only a single camp which had been made during the same summer, most of the Indian signs being two or more years old.

Arrangements for journey to Pelly. All that now remained to be done was to make the best of our own resources. We, therefore, went carefully over all our stuff, separating out everything which was not absolutely essential, and making up the remainder in packs, together with as much food as could be carried. This done, we stowed a great part of our camp equipage, together with some provisions, in a strong log *câche*, which was constructed for the purpose in the bay immediately south of the mouth of the Finlayson,

and moved round to the north side of the delta of that stream, to what we believed to be the best point from which to start. We then hauled out our two boats, and on the 17th and 18th of July carried our remaining stuff to a point some miles up the Finlayson and above the cañon and cascades, which render its lower part utterly impassable. Here we set up the Osgood canvas boat, which we had also carried over. Into this a portion of our stuff was put, and two of our Coast Indians were instructed to endeavor to track it up the shallow and winding stream, while the rest of the party found their way as best they could along the valley, with heavy packs. The walking was extremely fatiguing on account of the deep moss, alternating with brush and swamps, and as in addition, the weather was very warm and the mosquitoes innumerable, our rate of progress was slow. On arriving at the forks of the stream we unfortunately took the wrong branch for several miles, leading to some loss of time, but we eventually reached a lake which we recognized as Finlayson Lake, on July 24th. The canvas boat did not arrive till the evening of the next day, as great difficulty was met with in getting it up the shallow stream, which was badly blocked with fallen trees. In the meantime, observations for latitude and time were taken, and a raft was constructed on which the stuff might be floated to the head of the lake, which lay in the general direction of our route. Difficult land carriage.

The lake proved to be nine miles and a-half in length, and near its head we again found the ruins of a Hudson Bay *câche*, but no appearance of a trail. Having selected the most promising looking place from which to continue our journey, we took out the raft-sticks, in order that they might remain dry and serviceable for our Indians on their return, and made a second small *câche* of provisions. The Osgood boat being almost worn out by its hard usage on the Finlayson, and being besides quite too heavy to carry overland in addition to our other stuff, was also drawn up and abandoned. Reach Finlayson Lake

Soon after leaving the lake we fell upon small streams which evidently drained toward the west, and about noon on the 29th of July we had the satisfaction of reaching the bank of the Pelly River. From this place our five Coast Indians were sent back with instructions to take back to Mr. Reed, at Dease Lake, the articles left in the *câche* on Frances Lake, and this duty, we subsequently learned, they faithfully performed. Reach the Upper Pelly.

Having constructed a canoe from the canvas brought over for that purpose, we began the descent of the river on the 1st of August.

The above is a summary of our proceedings from Frances Lake to the Pelly. I now feel convinced, that if we had had Indian guides, we might in all probability have shortened the land carriage and possibly Probable better route.

have found a travelled Indian trail, by following up the waters tributary to the west arm of Frances Lake. It remains to give some notes of the country actually traversed.

Mountains.

Though the region between Frances Lake and the Pelly may be described as a mountainous one, no very high summits were seen, the elevations being, as a rule, rounded and regular in outline, and forming broad, plateau-like areas above the timber-line in some places. The Too-tsho Mountains, which run along the east arm of Frances Lake nearly due north, appear to turn more to the westward beyond the head of the lake, but the line of travel followed toward the Pelly still diverged rapidly from this, the culminating range of the district, and the general direction of the principal ridges in the vicinity of the Finlayson River is not far from east-and-west.

General character of the country.

It is probable that the general character of the country here met with fairly represents that of a wide belt to the west of the Frances River and north of the Liard, including the Campbell and Simpson Mountains and their vicinity. The mountains are about equal in altitude to those last mentioned, averaging from 5000 to 6000 feet. The country is traversed by wide, wooded valleys, of which that occupied by the Finlayson is here the principal. The climate evidently becomes less moist as Frances Lake and the vicinity of the Too-tsho Mountains are left, and dry, gravelly terrace-flats, with *Pinus Murrayana*, are not uncommon on the upper part of the Finlayson. Larch was observed in places for about half the distance up the river toward Finlayson Lake, but was not seen further west. White spruce is still the most abundant tree, and grows as large as along Frances Lake. The black spruce also, however, occurs, and *Abies subalpina* becomes the common and characteristic tree near the upward limit of forest growth on the mountains, which here occurs at about 4200 feet. Grassy swamps are found in a number of places, and a good growth of grass is also met with, where areas have been denuded of forest by successive fires, so that should it ever become desirable to use horses on this portage, they might be maintained without difficulty.

Character of Finlayson River.

The lower part of the Finlayson for about four miles, near its mouth, forms a series of rapids and small cascades in a narrow, rocky gorge, making in this distance a total descent of 300 feet to the lake. Above this cañon it is rapid for several miles, with gravelly bars, and quite shallow, but further up it becomes a narrow and often deep stream, flowing between muddy or sandy banks. At twenty-two miles from its mouth it divides into two nearly equal branches, the northern of which comes from *McEvoy Lake*, the southern from Finlayson Lake. Each of these streams, at their confluence,

is from twenty-five to thirty feet in average width and about two feet deep. The northern branch, however, soon becomes shallow, rapid and stony, while that coming from Finlayson Lake is extremely crooked, winding in all directions in a flat valley about a mile in width, and is besides, as already mentioned, very badly blocked by fallen trees.

View from a mountain.

From the summit of an isolated, bare-topped hill, which occupies the angle between the two streams, and rises about 1200 above the valleys, an excellent view of the surrounding country was obtained. To the north-eastward, broken masses of high, rugged mountains, patched with snow, limit the horizon. These are evidently connected with the Too-tsho Range, but appear to form an irregular western spur, which is not continued to the west of north. The intervening district, as well as the whole country to the south, is occupied by bare-topped, rounded mountains and ridges of less elevation. Amid these hills the round or flat-bottomed valleys of the streams extend, showing here and there the paler green of a patch of meadow. The most remarkable feature is, however, a tract of low, level country, in which McEvoy Lake and the head of Finlayson Lake lie. This runs nearly due east-and-west, and appears to continue in the former direction till it intersects the northern continuation of the valley of the west arm of Frances Lake, and is also observable to the west of the head of Finlayson Lake. It is intersected throughout by numerous small lakes or ponds and swampy meadows.

Character of Finlayson Lake

Finlayson Lake (*Tle-tlan'-a-tsoots* of the Indians) is nine miles and a-half in length and rather irregular in form. Its elevation above sea-level is 3105 feet, as determined by our barometer readings, and it may be regarded as occupying the summit of the watershed between the Mackenzie and the Yukon, as no stream of any importance enters it. The country about it is all rather low, but is diversified, to some extent, by wooded ridges and hills, which rise highest near its upper end. The water is apparently shallow throughout, and had, in consequence, a much higher temperature than that of Frances Lake. It is well stocked with white-fish and lake trout, and also, no doubt, with the other species found in Frances Lake. A dead amia, eighteen inches long, was also found on the shore.

The immediate shores of the lake are generally quite low and often swampy, and the country is covered with small, poor timber, much of which has been killed by fire. A pretty well marked terrace, at 100 to 150 feet above the water, runs nearly all round the lake, and at the head are irregular, low, lumpy ridges and islands, which evidently represent moraine accumulations. No rock-exposures were anywhere seen along the lake-shore.

The water-shed.

The distance from the head of the lake to the nearest point on the Pelly, in a straight line, is about fifteen miles, but the low tract of country already referred to runs some miles to the south of such a line for the greater part of the way. The actual watershed in this low country is probably not fifty feet above the lake, but there is no evidence that the lake ever discharges toward the Pelly. Its height above sea-level is about 3150 feet. Small streams rising to the west of the lake, flow together to form a respectable brook about half way across. This occupies a wide, terraced valley, the ridges bordering which gradually diverge as the Pelly is approached, and the river itself is bordered by undulating terrace-flats several miles in width.

Country west of Finlayson Lake

On ridges west of the head of Finlayson Lake *Abies subalpina* becomes moderately abundant, but the white and black spruce are still the characteristic trees, and the former is well grown in sheltered valleys. No larch or black pine were seen on this part of the portage. The western yellow pond-lily (*Nuphar polysepalum*) was observed in great abundance in a small inlet of Finlayson Lake, and on the hills beyond *Polymoneum pulchellum* and *Mertensia paniculata*, with *Potentilla fruticosa*, were noted as specially abundant flowering plants. The vegetation in the vicinity of the Pelly was much further advanced than any we had yet seen, and the climate of the valley is evidently more favorable than that of the watershed region. The soil of the river-terraces is a fine, silty material, which, judging from the luxuriance of plant growth, must be very fertile.

Geological notes.

In consequence of the width of the valleys and the mantle of drift deposits, few rock-exposures were met with along the whole route from Frances Lake to the Pelly, and those examined consisted wholly of schists or schistose argillites, associated with cherty quartzites in some places, and generally of blackish or grey colors. The gravel wash in the various smaller streams and the rock *débris* met with on slopes of hills and elsewhere, consisted also predominantly of similar materials, and it would appear that the whole of this country is underlain by rocks resembling those described on Frances Lake and part of the river of the same name. A reddish argillite was noted as locally abundant in some streams entering the Finlayson on the south. Pebbles and small boulders of grey granite are not uncommon, but all appear to have been transported from a distance. In addition to the rocks above described, the gravel beaches on Finlayson Lake show numerous fragments of grey-blue limestone, some of which contain obscure fossils. Green serpentine, like that of the vicinity of Dease Lake, and exhibiting minute veinlets of serpentine-asbestos, also a few pebbles of reddish serpentine, were also noted here, and fragments of a peculiar white quartz-porphyry are not uncommon. Large pieces of

Rocks of Finlayson Lake

the same stone were afterwards found on the hills to the west of the lake, but it was not anywhere seen in place. Quartz-vein-stuff is everywhere very abundant, and on the terrace overlooking the Finlayson, on the north side, three miles below the lake, a large mass of quartz occurs in place. The extent of this mass of quartz could not be ascertained, as it protruded from the soil only in isolated spots over an area several hundred feet in length and breadth. A few specimens were collected, but on assay proved to contain neither gold nor silver. **Massive quartz.**

One of the most notable features of this watershed region is the great quantity of detrital material or drift with which the whole is covered. On the lower part of the Finlayson, irregularly bedded, clayey, gravel deposits, containing large glaciated stones and resembling boulder clay, were seen; but elsewhere stratified gravels and sands are generally shown in any scarped banks which occur. Well rounded gravel was found scattered over the very summit of the isolated mountain at the forks of the Finlayson, above referred to, at a height of 4300 feet above the sea, the material being of varied origin and including granite. No distinct terraces were found on this mountain, but terraces were noted further down the valley on the slopes of higher hills, at a height equal to, or greater than, that of this place. The evidence appears to be conclusive that a body of water in later glacial times extended quite across the Pacific-Arctic watershed in this region, standing at a level more than 1000 feet above it. Glacial striation, in a bearing parallel to that of the valley, was noted on the surface of the quartz mass previously alluded to, but the direction of motion of the ice could not be determined. **Superficial deposits of the watershed.**

Upper Pelly River.

Our first camp on the Pelly was situated in lat. 61° 48′ 52″, long. 131° 01′ 06″, the height of the river being at this place, as approximately determined from the mean of a number of barometer observations, 2965 feet. The river is here 326 feet wide, with a current slightly exceeding two miles and a-half an hour, and a middle depth of seven feet. An approximate estimate of the discharge placed it at 4898 cubic feet per second. The river had evidently fallen very considerably since the early summer and was probably at or below its mean stage. The water is here nearly clear, with a light brownish tinge. From explorations made at the time of the existence of the Hudson Bay post, as well as from Indian report, the river is known to be navigable by boats for a considerable distance above this point, and to rise in two lakes, the position of which is approximately indicated on the map, according to **Upper Pelly River.**

Mr. Campbell's sketch. Our camp was about two miles above the mouth of the stream which has already been mentioned as rising on the portage near Finlayson Lake, at the angle between which and the Pelly the old post named "Pelly Banks" was situated. We saw no trace of the buildings which formerly existed, though the old site might, no doubt, have been determined by a little search, had we thought it worth while to devote the necessary time to it.

"Pelly Banks" to Hoole Cañon.

Appearance of the country.

From our initial point, above mentioned, to Hoole Cañon and Cañon, is a distance of thirty-one miles in a straight line, the direction of which is a few degrees north of west. The river, however, forms a wide curve to the south of this line, and is besides very tortuous in detail, the actual distance, following its course, being fifty miles. The main orographic river-valley is here not confined, as is so often the case, between parallel ranges of mountains. There is on the contrary a wide tract of irregularly hilly country, which is bounded to the south by a well-defined mountain range at a distance of ten to twelve miles. This range is crowned by a series of square-outlined pyramidal peaks, which are probably composed of stratified rocks. It is proposed to distinguish it as the *Pelly Range.* To the northward, no definite boundary to the low hilly region can be seen. The actual trough in which the river meanders, however, is scarcely more than a mile in average width, and is generally bordered by terraces a hundred feet or more in height.

Hoole River.

Thirty-three miles, by the course of the river, below our starting point, a tributary comes in from the mountains to the southward, about fifty feet wide by one deep, and very rapid. This is identified as Hoole River.* Its water is bluish in tint, and clearer than that of the Upper Pelly, which by this time has become slightly turbid from material derived from its soft, silty banks. The river, between our first camp and Hoole River, has a rather moderate current, scarcely exceeding four miles and a-half an hour, though with several little "riffles" or small rapids.

Rapid.

Just below the mouth of Hoole River is a rapid about 600 feet long, with a total fall estimated at about ten feet. There is an easy portage on the right or north bank, but a fair-sized boat might run through without danger at most stages of the water. As a precautionary measure, we lightened our canvas canoe, of the behavior of which

* So named by Mr. Campbell after his interpreter. Mr. Campbell, on his original sketch and on Arrowsmith's map, in the construction of which it was used, has named a number of the tributaries of the Pelly. It has been found difficult to identify some of these, but all have been placed on the accompanying map, after a careful comparison.

in bad water we had had at the time no experience. From this rapid to Hoole Cañon the water is swift, and there are several little rapids.

The banks and beaches of the Pelly above Hoole River, are generally silty or muddy, though the strength of the current is sufficient to produce well-washed gravel-bars in mid-stream. Below that point the banks and beaches are also as a rule gravelly, in conformity with the swifter flow of the stream.

Vegetation. The banks along the south side of this part of the river, are for the most part densely wooded, and where shady and damp the growth of timber is small and scrubby, with much black spruce. The banks on the opposite side are very different in appearance. Those above Hoole River show numerous open, grassy patches, and below that place grassy slopes preponderate over the wooded area, the grass having the characteristic growth and dry, tufted appearance of "bunch-grass." The trees are similar to those found along the rivers previously described, except that *Pinus Murrayana* and larch do not occur, and but a single white birch was noted, near the mouth of Hoole River. Groves of cottonwood of medium size cover some of the flats. **Frozen soil.** In one or two banks into which the river was cutting, and where the surface was covered with a dense, mossy growth, frozen soil was observed. The depth to which it extended could not be ascertained, as it went below the water-level of the stream.

Rocks represented. Above the mouth of Hoole River the rock exposures are few and inconsiderable. Near the mouth of Campbell Creek a yellowish-weathering irregularly silicified dolomite was observed in several low outcrops, together with green-grey, slightly lustrous schists, and similar schists were seen in one or two other places on this part of the river. The composition of the gravel of the river-bars may be accepted as indicating in a general way the character of the formations of the drainage area of the upper river. These include fragments of schists, quartzites and argillites of the same kind as before described on the Frances, with grey, fine-grained limestone, some pieces of coarse white marble, and occasional small pebbles of the same peculiar quartz-porphyry seen on Finlayson Lake. There are also represented several varieties of granitoid rocks, the most abundant of which has a coarse gneissic lamination, with whitish or greenish mica and large, white, porphyritic felspar crystals, round which the layers of the rock bend. This peculiar granite or gneiss is probably derived from the head-waters of the main river, and often occurs in large boulders, which can scarcely have been carried by the stream, and have probably been transported during the glacial period.

Basaltic area. At the rapid at the mouth of Hoole River low bluffs of dark-brown basalt appear, and the same rock crops out in several places further down the river, extending probably to within two miles of Hoole Cañon, though the lower exposures have rather a dioritic appearance, somewhat different from those first noted. The horizontal extent of this local development of basalt is approximately indicated on the map, but as the country to the north is here all low, its limit in that direction is entirely hypothetical. This is probably the first occurrence of basalt on the river, as no basalt pebbles were seen above this place. The basalt is often amygdaloidal or vesicular, and contains chalcedony, calcite and some fibrous zeolite, but is scarcely at all columnar.

Scarped banks. Above the mouth of Hoole River, frequent scarped banks exhibit white or grey bedded silts, associated with or underlain by stratified gravels, with a dark-grey, earthy matrix. These latter deposits often hold large boulders, and observations made further down the river appear to show that they represent the boulder-clay.

Between Hoole River and the cañon, the silts are scarcely seen in the banks of the Pelly, being replaced by gravelly and coarse sandy deposits.

Hoole Cañon to Ross River.

Hoole Cañon. At Hoole Cañon, the river makes a knee-like bend to the north-eastward, and is constricted between rocky banks and cliffs about a hundred feet in height. These render it impracticable to use the line, and as the water is very rough and dangerous, it was found necessary to carry not only all our stuff, but the canoe as well, to the lower end of the cañon. The distance by the river is about three-quarters of a mile, by the portage half a mile, the highest point being one hundred feet above the river. The portage is on the south side of the river, and we found traces on it of skids which had been laid by the Hudson Bay Company many years ago, but no sign of its having been employed by the Indians, who in all this district generally travel by land, making rafts when they are obliged to cross any of the larger rivers.

Ross River. Sixteen miles and a-half below the cañon in a straight line, or twenty-three miles by the course of the Pelly, is the mouth of a river which is identified as the Ross River of Campbell.* This stream, which comes from the north-eastward, is to all appearance as nearly as possible equal in volume to the Pelly, having a width of 290 feet, with a current of four miles and a-half an hour. Its water is turbid and milky, and colder than that of the Pelly, leading to the belief that it is not derived from lakes like that stream, or that if lakes do

* So named after Chief Factor Donald Ross.

occur on its upper waters, they are much less in area than those of the Pelly. Its size would indicate that it may rise in the same distant range with the Pelly, but no long view was obtained up its valley, which is narrow and bordered by high, steep hills at its mouth. Midway between the cañon and the Ross, Ketza River,* a swift stream, about forty feet by one foot, joins from the south. Like other streams from that direction, it carries clear, blue, mountain water, and brings down quartzites, argillites and schists of the usual character, together with a great abundance of quartz-gravel. Character of county.

The Pelly, between the cañon and Ross River, is swift throughout, with numerous little rapids. To the south of the river there is still a wide extent of low, wooded country between it and the continuous range before referred to as the Pelly Mountains. To the north the view is more limited, particularly near the mouth of the Ross River, owing to the existence of a long, steep ridge, parallel to the course of the Pelly, and from 600 to 800 feet in height above it. The southern face of this ridge, which is cut through by the Ross River, is more than half, open grass land, and would afford excellent pasturage. Rocks.

The rocks of Hoole Cañon and its vicinity are chiefly white marble, associated and interbedded with grey and black cherty-looking quartzites, which are often thin-bedded and sometimes rather schistose, and precisely resemble the Câche Creek quartzites of southern British Columbia. Further down the river are occasional exposures of greenish and grey schists and schistose argillites. The rocks along this part of the Pelly strike nearly parallel to its main direction, or about north-west by south-east, and are either nearly vertical or have dips to the south-westward. Stratified gravels are seen in a few places in scarped banks, but silts are not here specially characteristic.

Ross River to Glenlyon River.

From the mouth of Ross River to the Glenlyon River, the general course of the Pelly is almost direct, on a bearing of N. 50° W., the distance being sixty-four miles. In consequence of the number of minor flexures in the stream, this is, however, increased by the river to eighty-two miles. Ten miles below the Ross, following the river, a stream, *Lapie River*,† sixty feet wide by one foot deep, and resembling in its general character and colour of water Hoole and Ketza rivers, comes in from the south. Twenty-three miles from the same point a smaller tributary joins from the north, which is supposed to be the Orchay of Lapie River. Orchay River.

* So named by Campbell, after one of his faithful Indian companions; not Kelzas, as shown on Arrowsmith's map of 1854.

† This stream was not named by Campbell. I call it Lapie River, after one of his Indians, he having given the name of the other (Ketza) to a neighboring tributary.

Campbell. This is about twenty feet wide by six inches deep, and carries clear, brownish water, doubtless derived from a lake or lakes. Ten miles further, on the same side, is a valley running to the north, which probably brings in a moderate sized stream. But this falls into a slough, behind islands, and was not seen.

Features of the country.

All the way from the Ross to the Glenlyon the Pelly is closely bordered on the north by ridges and hills of considerable height, which become mountains of 4000 to over 5000 feet before the last-mentioned stream is reached. These entirely preclude any outlook over the country on that side. To the south, the important and well-marked Pelly Range is continued to a point opposite the Orchay River, where it appears to terminate in a group of mountains lower than those of its eastern part, but still from 5000 to 6000 feet in height. These are situated at a distance of about six miles back from the river, the intervening country being occupied by lower, wooded hills and broken country. The forms of the mountains are rather bold, consisting of steep crests and ridges, with intervening narrow, V-shaped gorges, and they appear to be grassed or covered with low, herbaceous growth, giving them a general greenish tint. There are few bare, rocky summits, and the whole appearance is that of a range shaped by normal processes of denudation from schistose or other crumbling rocks of a stratified character and nearly uniform hardness. They still carried a few patches of old snow on the 4th of August. The higher portions of this range to the eastward, present a rougher and almost serried outline, but there are not even there any exceptionally high points, and the slopes of the peaks are extremely uniform. Beyond the western termination of this range, for a distance of about twenty miles, no mountains were seen to the southward from the river-valley. From the fact that evidences of a more humid climate were found along the corresponding length of the river, it is highly probable that a somewhat important gap occurs in this direction, of sufficient width to admit the entrance of the moisture-bearing winds. The greater humidity of this part of the valley is particularly marked by the densely wooded character of the slopes on the north side of the river.

Pelly Range.

Gap to the southward.

Beyond the gap above referred to, a low mountain-range appears on the south side of the river, not in line with that last described, but quite close to the river, which here, for a number of miles, flows in a valley between two mountain axes.

Notes on the river.

The Pelly, for rather more than half the distance between the Ross and Glenlyon, continues to be pretty swift, and is much divided among islands and gravel-bars; the remaining part is comparatively tranquil, with the exception of the rapids in the immediate vicinity of the Glenlyon. The forest growth throughout is much like that previously

described, save that the birch is now moderately abundant, and the black pine (*P. Murrayana*) appears, coming in first on dry northern slopes thirteen miles eastward from the Glenlyon. Cottonwood, aspen, alder, spruce and willows are the prevailing trees on the river-flats, which are usually about ten feet above low-water level. Frozen soil was again seen in several places along the shady side of this part of the river, extending from about eighteen inches below a mossy and peaty sod to the water-level, with a depth of ten feet or more. Some of these banks were being rapidly undercut by the water, which thaws the soil wherever it comes in contact with it, and causes large masses, with the superincumbent sod and trees, to fall into the stream.

Black pine.

Frozen soil.

The rapids above alluded to as near the Glenlyon are two in number. The first occurs in an S-shaped bend about two miles east of the Glenlyon; the second just below the mouth of that stream. The upper rapid is wide and rather shallow, with some rocky impediments. It is easily run with a canoe, but at low stages of the river, doubtfully passable for a steamer, unless of light draft. The current in the second rapid strikes full on the face of a rocky bank on the right of the river, and forms a heavy confused wash in consequence, but is otherwise unimpeded and deep.

Rapids.

The rocks seen along the Pelly, between the Ross and Glenlyon, while resembling in a general way those previously described, differ in their greater alteration and in the evident importance in their composition of products originally of volcanic origin. The most abundant are blackish-grey and greenish quartzites and schists, often more or less micaceous, and in places passing into true mica-schists. Three and a-half miles west of the Ross River, on the left bank, are exposures of massive, dark, leek-green serpentine, associated with green serpentinous and quartzose schists, and a spotted white and green rock, which may be a much decomposed diabase or diorite. One portion of the bank shows at least a hundred feet in thickness of nearly pure serpentine, but no asbestos veins were seen here. Thirty-six miles west of the Ross a very peculiar purplish felsite was noted. It is schistose and slightly micaceous in the division planes, besides being porphyritic with irregular white felspar masses. Four miles east of the Glenlyon, a close-grained, banded, white-and-grey felsite occurs, in a much shattered exposure, and is probably a fine, altered volcanic ash. All these rocks evidently form members of a single series, and though with numerous local irregularities, strike in a general way parallel to the course of the river. The circumstances tend to show that they are on the whole stratigraphically higher than those seen further up the river, but it is not certain that the dips are normal.

Geological features.

Laramie or Cretaceous rocks.

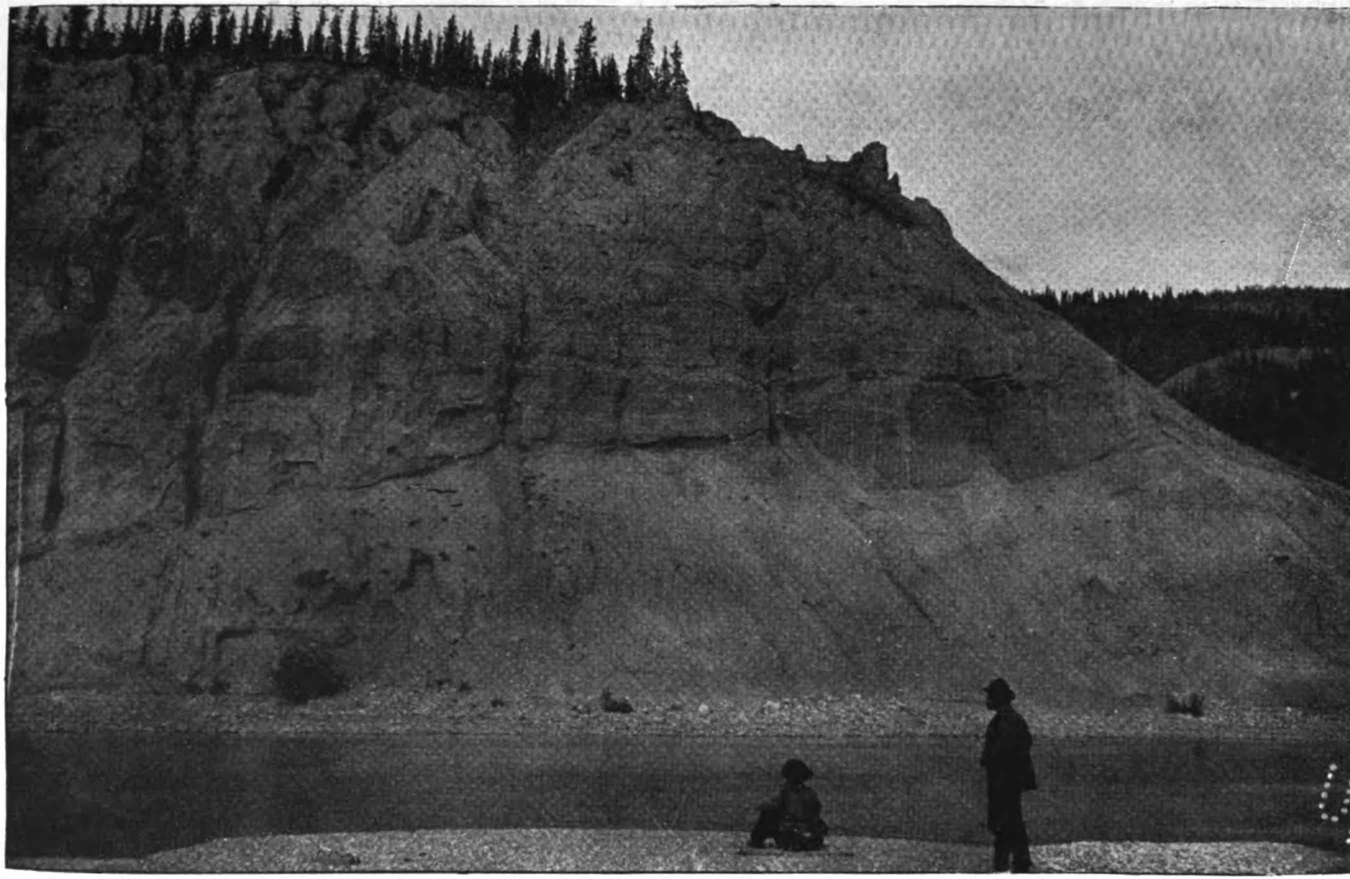
The most interesting fact developed on this part of the Pelly is, however, the occurrence of rocks of Laramie or Cretaceous age. These were noted in a single low exposure on the south side of the river, twenty-seven miles and a-half west of the mouth of Ross River. They consist of black carbonaceous or possibly plumbaginous shales, rather hard, and interbedded with grey-brown sandstones, the whole dipping nearly due south at an angle of forty-five degrees. But this single occurrence of rocks of this character was found, and no rocks are seen for several miles up or down the stream, so that the area characterized by the formation to which they belong is uncertain. Sir William Dawson writes as follows of the fossils obtained here:—"The few specimens examined are full of impressions of dicotyledonous leaves, much crushed and imperfect. One has the venation of *Corylus MacQuarrii* (Forbes). Another seems to be a *Juglans*, near to *J. acuminata* (Braun). Both of these species are said by Heer to occur at English Bay, Alaska, and also on Mackenzie River. The determinations cannot, however, be considered as certain."

Fossil plants.

Superficial deposits.

Fine sections of the drift deposits frequently occur along this part of the Pelly River, forming scarped banks from eighty to a hundred and fifty feet in height, and at times a quarter of a mile or more in length. The stratified gravels, with grey or brownish earthy matrix, which have previously been described, were seen just above the mouth of Ross River to be interbedded with and overlain by silts of the usual character. A few miles below the Ross they were first seen in association with indubitable boulder-clay, and thence down stream, the earthy or clayey gravels and boulder-clay form the lower portion of most of the scarps, being capped by bedded silts, which in some places are fifty feet in thickness. The stratified earthy gravels and boulder-clay are interchangeable and may be considered as constituting a single formation. These gravels are sometimes interbedded with rude layers of boulder-clay, while in other sections they occur in the bottom of the bank, with massive-looking boulder-clay above them, and in yet other instances these conditions are reversed, and the gravels pass above into the bedded silts, which everywhere constitute the upper member of the glacial series. When the matrix of the gravels becomes clayey, they closely resemble boulder-clay in composition, but do not often hold such large stones as the latter occasionally does. The stones of both the gravel and the boulder-clay are more or less completely water-rounded, and striated stones were seldom seen along the river. The gravels above referred to are quite distinct from the old river-valley gravels, which also occur at various levels, sometimes as the highest member of the section in scarped banks, in other cases forming the substratum of river-flats. With the appearance of

Peculiarities of boulder-clay



G. M. DAWSON PHOTO., AUG. 4, 1887.

G. E. DESBARATS & SON, ENGRAVERS & PRINTERS, MONTREAL.

DRIFT BLUFF, UPPER PELLY RIVER, AT MOUTH OF LAPIE RIVER.

Lower part of bluff boulder-clay, irregularly overlain by earthy stratified gravels, these followed in ascending order by stratified silts.

the boulder-clay the scarped banks begin to assume a characteristically castellated appearance, standing often in series of nearly vertical buttresses and pillars, with deep intervening gullies.

Glenlyon River to Macmillan River.

For the purpose of description, the next convenient length of the Upper Pelly which may be taken, is that extending from the Glenlyon to the Macmillan River.* This again naturally sub-divides itself into two parts, the first with a general bearing of N. 53° W., twenty-eight miles and a half, in continuation of the general course of the upper river, the second about N. 77° W. thirty-three miles. The total distance, following the course of the river, from the Glenlyon to the Macmillan, is ninety-one miles. The tributary streams in this distance, again measuring by the course of the Pelly, down stream, are as follows:—Glenlyon River, forty feet by one foot. Eight miles and a-half below, stream on the north, sixty feet by six inches. Twelve miles, tributary from the south, twenty feet by three inches. Seventeen miles, on the south, dry torrent bed. Twenty miles and a-half, on the south, ten feet by three inches. Thirty miles on the north, thirty feet by six inches; the Earn River of Campbell. Forty-seven miles on the south, thirty feet by three inches; probably the Tummel River of Campbell. From this point to the Macmillan no tributary streams were observed, the country to the northward evidently draining toward the last-named stream, and that to the south, at no great distance, being in all probability within the drainage-basin of the Lewes. Tributary streams.

The above estimates of the sizes of the streams refer to the date at which we saw them, in August, when most appeared to be at or near their lowest stages. For about twenty miles below the Glenlyon River, the Pelly is more than usually free from abrupt bends, and few islands are met with. It is bordered to the south by a range of mountains, which may be named the *Glenlyon Mountains*, the highest points of which somewhat exceed five thousand feet. Lower irregular hills border the north bank, and these, as usual, show extensive grassy slopes on the southern exposures. At the distance just mentioned from the Glenlyon, the river turns abruptly to the northward, making an S-shaped bend, and cutting completely through the ridge which has previously bounded it on that side. After a sinuous course of about fifteen miles (about midway in which it receives the Earn River), to the north of the ridge, it turns again with equal abruptness to the southward, rounding the west point of the Glenlyon Mountains. The Detour.

* Of Campbell, named for Chief Factor Macmillan.

ridge, which here dies away. This peculiar flexure is distinguished on the map as *The Detour.* To the south of the ridge is a wide valley, which lies in the general direction of the river, and which, though now apparently floored by drift deposits, doubtless represents a pre-glacial valley of the Pelly. The distance from bend to bend of the river, through this disused valley, is eight miles and a-half, and the height of its floor above the water-level was estimated at about two hundred feet. As far as the lower end of The Detour the current is rather swift and there are a number of little riffles, some of which might be called rapids, though none are of a character to impede navigation.

Approach to Macmillan River.

From The Detour to the Macmillan, the Pelly has a current averaging not more than three miles an hour, though attaining four miles in a few places. The country begins to open out to a greater extent than found anywhere on the upper river, and is diversified only by comparatively low and irregular hills. About fifteen miles eastward of the Macmillan is a wide low gap opening to the north, by which the Indians evidently cross over to the valley of that river, as several large rafts were seen here on the north bank. Between this place and the mouth of the Macmillan, the river becomes again rather strictly confined between ranges of hills, but just below its confluence it turns sharply to the north and is broken up into several channels among a number of low, wooded islands.

Confluence of the rivers.

The Macmillan and the Pelly valleys coalesce at an acute angle at the western point of the range of hills which alone has separated them for some distance, and the two streams must run nearly parallel for many miles above their junction. The Macmillan is bordered to the north by a well defined range of low mountains, which continues to the westward for about ten miles as the bordering range of the united streams. At the confluence, the Pelly appeared evidently to be somewhat the larger river at the time of our visit, and it is probably so at all properly comparable stages of water. The inequality in size can not, however, be very great. The width of the Macmillan, just above its mouth, was found to be 455 feet, the rate of the current, which is greater than that of the Pelly at the same place, was 2·7 miles per hour. The Macmillan water is much more turbid than that of the Pelly, and of a yellowish colour. The temperature of both rivers was identical on the ninth of August, being 54° F. It may probably be assumed from this circumstance that the origin of the rivers is similar, and that the Macmillan, like the Pelly, rises in or flows through considerable lakes, in which the water is warmed to a like extent. The suspended matter of the Macmillan may be entirely due to the washing away of silty banks, which is the usual cause of the turbidity of streams in this district. The upper part of the Mac-

G. M. DAWSON, PHOTO., AUG. 9, 1887. G. E. DESBARATS & SON, ENGRAVERS & PRINTERS, MONTREAL.

ON UPPER PELLY RIVER, NINETEEN MILES ABOVE MACMILLAN.

millan has never been explored, but its size would indicate that it may rise as far to the eastward as the Pelly, and probably, like it, in mountains representing the western ranges of the Rocky Mountains. We do not, however, know to what extent this river shares with the Stewart the drainage of the comparatively low country to the northward. I afterwards met a couple of miners (Messrs. Monroe & Langtry) who had ascended the Macmillan for several days in a boat, but not finding encouraging "prospects" had returned. They reported the existence of a large area of low land with good soil, and had met with no impediments to navigation as far as they had gone. Macmillan River.

Ten miles above the mouth of the Macmillan we encountered a couple of Indians, father and son, working their way up the Pelly with a small dug-out canoe. They were the first human beings we had met with in the country since leaving the mouth of the Dease River, forty-three days previously, but as we were totally unable to communicate with each other except by signs, it was impossible to obtain any definite information from them. They were evidently quite at a loss to know whence we had come, and evinced a peculiar interest in examining our little canvas canoe. Meet Indians.

The Glenlyon Range appears to be throughout granitic. Its base does not touch upon the river, but the general aspect and uniform grey colour of its higher parts is that of the granitic mountains of this region. Its composition is also indicated by the character of the material brought down by the Glenlyon River and other rapid streams which rise on its slopes or in its valleys. This is largely, and in some cases almost exclusively, composed of granite of very uniform lithological character, grey in colour and generally hornblendic. The same rock is met with in place on the Pelly, about half way from The Detour to the mouth of the Macmillan, beyond the termination of the range itself, but precisely in the continuation of the line of its axis.* The rocks exposed along the Pelly itself, between the mouth of the Glenlyon and the granitic exposure just alluded to, and which may be regarded as a whole as occupying the northern flank of this granitic range, are more varied in character than those met with on the upper part of the river. Nothing can be said as to their order of superposition, for while the river nearly follows the main direction of the strike, the locally observed attitudes of the strata of the several isolated places where they were noted are very irregular. This is particularly the case in the vicinity of The Detour. The rocks comprise greenish and blackish schists and schistose quartzites, of varied aspect, generally somewhat more altered in appearance than usual. These are interbedded at the east end of The Detour with finely-banded white Geological features.

* See Appendix V. (Upper Pelly, No. 53).

marble and quartzite; and at ten miles west of The Detour, are somewhat extensive exposures of blackish and bluish-grey, rather flaggy and little altered limestones, in which, however, no fossils could be found.

Second range of granite. The range of hills which has been referred to as bordering the Pelly on the south, near the mouth of the Macmillan, is likewise composed of granite, which appears in several places on the river. This is of greyish and greenish-grey colours, and similar to that of the Glenlyon Range, though it apparently forms a distinct though parallel granitic axis. The rocks which immediately border this granitic axis to the north, though not seen in actual contact with the granite, have a more highly altered aspect than almost any of those seen further up the river, but the impression gathered from their examination is that they owe this alteration to the influence of the granite rather than that their character is an evidence of greater age. They comprise several varieties of rough, micaceous schists, which are highly quartzose, and evidently of clastic origin, as well as a much silicified, coarse grauwacke, and a pale-grey, speckled, silvery mica-schist, which breaks into thin laminæ. The last-mentioned rock is found on the north bank immediately below the Macmillan. Some distance further down, the river turns sharply to the south, and cuts across the whole width of the second granitic axis in *Granite Cañon*, presenting exposures of grey hornblendic granite for several miles, which, near the lower end of the cañon, becomes much shattered by jointage-planes.*

Granite Cañon.

Drift deposits. The drift deposits along the part of the river between the Glenlyon and Macmillan, resemble those previously described, the only marked change being in the substitution, in some sections to a considerable extent, of sands for the silts before so characteristic. Stratified clayey gravels and boulder-clay occur, with relations similar to those noted on the upper river, but in some sections gravels and sandy silts are interbedded, the bedding at times being flexuous, and even contorted in character. All these materials are below the ordinary valley-gravels and sands of post-glacial age.

Glacial striation. Six miles below the Glenlyon, the first distinct case of glacial striation and ice-rounded rock-surfaces met with on the Pelly was noted, and below this place similar evidences were found in a number of localities. The direction of striation in all cases closely accords with that of the main depression of the river-valley, though cutting across it obliquely where it turns north towards the Macmillan. The form of the surfaces is such as to show that the sense of the movement of ice was westward or down stream.

* See Appendix V. (Upper Pelly, No. 57.)

Macmillan River to Lewes River.

From the mouth of the Macmillan to the confluence of the Upper Pelly and Lewes rivers is a distance, in a straight line with a general bearing a few degrees south of west, of forty-six miles. A considerable portion of this part of the river is, however, extremely tortuous, and in consequence no doubt of the generally low character of the country, its flexures are not merely short, sharp bends from side to side of a trough-like valley, like those usually met with further up, but lax irregular curves of greater dimensions. The distance from the Macmillan to the mouth of the Lewes measured along the course of the stream is seventy-four miles. **Tortuous part of the river.**

Four miles below the mouth of the Macmillan, on the north bank, is a small log-cabin, the first sign of habitation we had seen. We afterwards ascertained that two miners had lived here during the winter of 1886-87. At five miles and a-half below the Macmillan the Pelly was found to be 754 feet in width, with a current of 2·3 miles per hour; a few miles below this the river turns south-westward and then nearly due south, entering Granite Cañon at thirteen miles from the Macmillan. The rocks met with in the cañon have already been alluded to. The cañon is about four miles in length, with steep, rocky, scarped banks and cliffs, 200 to 250 feet in height. In the cañon are several little rapids, but the water is deep, and with the exception of some isolated rocks, the navigation would be quite safe for steamers, even at a low stage of water. As the river is much confined, however, it is probable that pretty rough water may be found here during floods. Just beyond the cañon, or sixteen miles and a-half below the Macmillan, a small stream, about ten feet by three inches, enters from the south-eastward. The bed is wide, and it appears at seasons of flood to become a formidable torrent. At thirty-six miles from the Macmillan another small stream was observed on the south side, but with this exception, the river receives no further tributaries before meeting the Lewes. Judging from Campbell's sketch, this otherwise insignificant stream must be that flowing from Tatlmain Lake, which was probably a source of supply of fish for Fort Selkirk while that post was maintained. **Granite Cañon.** **Tatlmain Lake.**

After passing the ridge which is cut through by Granite Cañon, the country on both sides of the river for about fifteen miles is quite low. No mountains or high hills are in sight on any bearing to the westward, and wide terraces run far back from the river at heights of 150 to 200 feet above it. These are often lightly wooded, largely with aspen, and are clothed with a good growth of grass presenting a very attractive appearance. The soil is good, and at the time of our **Low country.**

Appearance of the country. visit the country was very dry. *Anemone patens* was seen here for the first time since reaching the Yukon basin, and *Elæagnus argentea* was also noted, both species characteristic of a rather dry climate. For the remaining distance to the mouth of the Lewes, the river is more closely bordered by low hills and ridges, which seldom exceed a height of 400 feet. At one place the stream is confined between high and somewhat rocky banks, but no rapid is met with. The southern slopes of the hills are generally open and grassy, and would afford excellent pasturage. The northern exposures are still pretty thickly wooded. Just above its confluence with the Lewes, the Pelly makes an abrupt turn to the south, and runs for several miles along the eastern base of a scarped cliff of basalt. From Granite Cañon to the confluence, the current scarcely exceeds two miles and a-half an hour.

Rock exposures For a number of miles below Granite Cañon, no rocks are met with along the river, but lower down there are frequent exposures, extending for some miles, of highly crystalline schists, which strike nearly east-and-west, parallel to the main direction of the river, with general high northward dips. These rocks differ considerably from any before seen, including dark, wholly-crystalline schists, holding hornblende or hornblende and mica. With these are associated considerable exposures of a peculiar dark-green chlorite rock, containing large mica crystals.

This rock is interbedded with white, coarsely crystalline marble, in some places, and is quite evidently the alteration-product of some stratified material which has doubtless, however been of volcanic origin. Nine miles above the confluence, by the course of the river, a great mass of impure serpentine comes out on the bank, and six miles and a-half above the same place, grey granite of the usual character is again met with,* and appears to constitute the hills to the east of the river for the remaining few miles of its course.

Serpentine.

Basalt bluffs. The basalt, which forms a plateau from 200 to 250 feet in height in the angle to the west of the Pelly at its junction with the Lewes, consists of several superposed flows, not always distinctly separable at a distance. It forms a mural cliff, with a long talus of angular fragments sloping down to the river-level, and though not very distinctly columnar where it fronts on the Pelly, becomes so below the confluence. The rock is brown in colour and often vesicular.

Superficial deposits. The bedded silts were seen above Granite Cañon, but are scarcely represented below it. Boulder-clay was noted in one place below the cañon, and the old stratified gravels in several places. The scarped banks along this lower part of the river are, however, chiefly composed

* See Appendix V. (Upper Pelly, No. 61.)

of well rolled valley- or river-gravels, which become much more important than before, and often constitute entire terraces up to forty feet in height.

A remarkable layer of fine white volcanic ash, which overlies the glacial deposits all along the Upper Pelly valley, as well as in that of the Lewes, has already been described on page 43 B.

Volcanic ash.

General Notes on the Upper Pelly River.

Length and fall of the river

The total length of the Upper Pelly, following the course of the river, from the point where we first reached it at the west end of Campbell's Portage to its confluence with the Lewes, is 320 miles. The elevation at the first-mentioned point is about 2965 feet, that at the confluence 1555 feet, giving a total fall of 1410 feet or 4·4 feet to the mile, a considerable portion of which, however, occurs in the numerous little rapids and riffles of its course. In Hoole Cañon the estimated fall is about twenty feet. Two hundred and eighteen islands were counted in the river, without including such gravel bars as are submerged at high water, and are consequently without vegetation. The general course of the river is remarkably direct, and it embraces two main directions, the first bearing N. 55° W., the second, N. 87° W. These are parallel to the principal orographic features respectively of the upper and lower parts of the country traversed, and appear to indicate the main slopes of the general surface of the region.

Navigability.

With the exception of Granite Cañon, where warping might have to be resorted to at one place, the river would be easily navigable for stern-wheel steamers as far up as the mouth of the Macmillan, and the latter stream is also navigable for a considerable though unknown distance. Above the Macmillan, I believe, no serious difficulty would be met with in taking a small stern-wheel steamer of good power up to the mouth of Ross River, and possibly as far as the foot of Hoole Cañon. A line might have to be carried ashore at a few of the stronger rapids, but the chief difficulty to be encountered would be from shoal water at low stages. Where the river is widely spread and swift, a depth of three feet could scarcely be found across some of the gravelly bars. The Ross River is a navigable stream at its mouth, but its upper part is quite unknown. Hoole Cañon is, of course, quite impassable for a steamer of any kind, and the rapid met with seventeen miles east of it, at the mouth of Hoole River, might prove to be a difficult one to surmount by warping, its fall being estimated at about eight feet. Above this point, the river is again, however, an easily navigable one

for small steamers to the furthest point seen by us, and possibly as far as the lakes.*

Tributaries from the south.

All the streams and small rivers flowing into the Pelly from the south and rising in or beyond the Pelly and Glenlyon mountains, are notably swift, and most of them are evidently subject to heavy freshets.

Timber.

Some notes have already been given respecting the character of the timber along the Upper Pelly. On the lower part of the river there are numerous groves on or not far from the banks, with good spruce up to two feet in diameter. Spruce of the same size is found also on the whole upper part of the river, but is relatively less abundant there.

Quartz.

As in the case of the Upper Liard and Frances rivers, quartz derived from veins is an abundant constituent of the gravel-bars of the Pelly, and numerous small quartz veins were observed in the rocks in many places. Where the granites are approached, the veins are found to cut all the rocks except these, and it appears that the development of the quartz veins is due to the same period of disturbance which has given rise to the uplift of the granite axes or their extrusion. Small "colours" of gold may be found in almost any suitable locality along the river, and "heavy colours," in considerable number, were found by us as far up as the mouth of Hoole River, in the bottom of a gravel-bed there resting on the basalt. The river has been prospected to some extent by a few miners, but no mining of importance has yet been done on it. Thomas Boswell, whom we met on the Lewes, informed me that he had found and worked for a short time, a bar which paid at the rate of $18 per diem. This was on a tributary which, from his description, is probably identified as the Ross River. Two miners only, Messrs. Monroe and Langtry, were at work on this river in 1887, and their operations were confined to the part below Granite Cañon, where they made on a couple of bars from $10 to $20 per diem to the hand. The headwaters of the Macmillan and Ross, and those of the Pelly itself yet remain unprospected, as well as the very numerous tributary streams of these rivers, in some of which "coarse" gold may yet be found.

Gold.

Coal.

From observations subsequently made on the Lewes, coal may be looked for in the Laramie or Cretaceous rocks near the river at the locality described on page 126 B.

* Dall, in his Alaska and its Resources, 1870, p. 278, gives a hypothetical itinerary of the Pelly River, making it head in Frances Lake. The Pelly, as shown on the map which accompanies the work, is evidently in part after Arrowsmith, and where it differs, (as in regard to the connection of Frances and Finlayson lakes with the Pelly), becomes misleading. It is difficult to understand why this part of Arrowsmith's map, bearing intrinsic evidence of proximate accuracy, should not have been followed throughout in the compilation of later maps, particularly as the Pelly had not been further explored since Campbell's time.

Confluence of the Lewes and Upper Pelly.

The country about the confluence, is generally speaking low, with extensive terrace-flats running back to the bases of rounded hills and ridges, of which none in sight probably exceed 1000 feet above the river. The moderate current which has been described as characteristic of the Upper Pelly for some distance above the confluence, continues to its mouth, but the Lewes is much swifter, and though at the point of junction divided among wooded islands, is evidently the larger stream, carrying a volume of water considerably greater than that of the Pelly, though probably less than twice as great (p. 18 B). It does not, however, necessarily follow from this that the Lewes is to be considered the principal head stream or continuation of the Yukon. The question of nomenclature and that of the position of the furthest sources of the Yukon, have, however, been referred to at greater length in another portion of this report. (p. 14 B). Comparison of the rivers.

The water of the Lewes is of a bluish, slightly milky cast and is easily distinguished from the brownish muddy colour by which the Pelly is characterized below its junction with the Macmillan. The temperature of the water in both rivers was found to be practically identical, on the 17th and 18th of August, at 7 p.m., being 59° F. Temperature.

The river below the confluence of the Pelly and Lewes averages about a quarter of a mile in width, and though its appearance is placid and there is no rough water, it is uniformly swift. An approximate cross-section made by Mr. Ogilvie showed the river to be, at the point in question, 25·76 chains wide, from bank to bank. Of this width about two-thirds had an average depth of ten feet, with a surface velocity of four miles and three-quarter an hour. The remaining third was occupied by shallow bars and slack water. Using the same formula as before (see p. 98 B) the volume of the flow is found to be approximately 66,955 cubic feet per second. Traces of the passage of flood-water in the preceding spring were found on the river-flat, about ten feet above the low-water level, which, with a velocity no greater than that above stated and assuming the banks to be vertical, would give a flood discharge of at least 167,400 cubic feet per second. It may be, however, that the water-marks observed were caused by the damming back of the river by an ice-gorge. Volume of united rivers.

The ruins of Fort Selkirk, formerly a post of the Hudson Bay Company, stand on a partly open flat, on the south side, at a short distance back from the river, and about a mile and a-half below the confluence of the Pelly and Lewes. One chimney, built of basalt blocks which must have been brought across the river, and cemented with clay which has been baked almost into brick by the combustion of the ruins of the fort, Ruins of Fort Selkirk.

still stands erect and uninjured. The lower part of a second is near it, and the fragments of several others strew the ground, which is partly overgrown by small aspens. These, and the traces of a couple of excavations which have probably been cellars, are all that now remain to mark the site of the buildings which were pillaged by Indians from the coast in 1852.

Discovery and Exploration of the Liard and Pelly.

Hudson Bay Company explorers.

Fort Selkirk, of which the ruins alone now exist, was at one time the most important post of the Hudson Bay Company to the west of the Rocky Mountains in the far north, and with the exception of Fort Yukon, it was the farthest permanent post ever maintained by the Company to the north-west. On previous pages of this report, frequent mention has been made of the former establishments of the Company in the Liard and Yukon region, and as Fort Selkirk is the last of these with which our route brought us in contact, a note as to the operations of the Hudson Bay Company may appropriately be given here. When we call to mind that our knowledge of the geography of the region described in preceding pages has been up to the present time almost wholly due to the explorations carried out by the officers of the Company in connection with these establishments, it becomes evident that the history of these explorations and the facts respecting the several posts are well worthy of record.

McLeod.

The circumstances attending the discovery of the Dease and Upper Stikine have already been given on page 83 B. Mr. J. McLeod, whose explorations in that quarter are there referred to, appears in the same year in which he reached the Stikine (1834), to have ascended the Liard as far as Simpson Lake, and to have brought back the information according to which the river was represented on Arrowsmith's map of 1850. It was to the energy of Mr. Robert Campbell, however, that the exploration of the Upper Liard and Yukon is almost entirely due. The only published account of Mr. Campbell's work, so far as I know, is that which appeared in the Royal Reader, Fifth Book, Toronto, 1883, p. 435, and which was reprinted, with slight alterations at Winnipeg in 1885, as a small pamphlet entitled "Discovery and Exploration of the Youcon (Pelly) River." From this source and from additional facts furnished by Mr. Campbell in answer to questions addressed to him, as well as from allusions in the unpublished journals of Chief Factor James Anderson, which have kindly been placed at my disposal by his son, the following brief account is drawn up.—

Campbell.

After the abandonment of Dease Lake post in 1839, Mr. Campbell was, in the spring of 1840, commissioned by Sir George Simpson to

explore the "north branch" of the Liard to its source, and to cross the height-of-land in search of any river flowing to the westward, especially the head waters of the Colville, the mouth of which on the Arctic Ocean had recently been discovered by Messrs. Dease and Simpson.

Mr. Campbell writes:—"In pursuance of these instructions, I left Fort Halkett [on the Lower Liard] in May, with a canoe and seven men, among them my trusty Indians, Lapie and Kitza, and the interpreter, Hoole. After ascending the stream some hundreds of miles, far into the mountains, we entered a beautiful lake, which I named Frances Lake, in honor of Lady Simpson. * * * Leaving the canoe and part of the crew near the south-west [*sic*] extremity of this [the west] branch of the lake, I set out with three Indians and the interpreter. Shouldering our blankets and guns, we ascended the valley of a river, which we traced to its source in a lake ten miles long, which, with the river, I named Finlayson's Lake and River." From this point, Mr. Campbell struck across to the Pelly, which he then named in honor of Sir H. Pelly, a Governor of the Company. Expedition to the Pelly.

"After reaching the actual bank of the river, we constructed a raft, on which we embarked and drifted down a few miles on the bosom of the stream, and at parting we cast in a sealed tin can, with memoranda of our discovery, the date, etc."

During Campbell's absence the remainder of the party built a house at the point between the two arms of the lake, which was then named "Glenlyon House," but was afterwards known as Frances Lake House or Fort Frances. Returning down the river, they met a trading outfit which had been despatched for them, at Fort Halkett, and turned back with it to Frances Lake, after sending out a roport of their proceedings. Establishment of Fort Frances

The Company now resolved to follow up those western discoveries, and in 1842 birch bark, for the construction of a large canoe to be used in exploring the Pelly, was sent up from Fort Liard. In the same year Fort Pelly Banks was constructed, or its construction begun, and early in June, 1843, Campbell left that place in the canoe which had been made, accompanied by Hoole, two French-Canadians and three Indians. Exploration of the Pelly.

They saw only one family of Indians ("Knife Indians") till they reached the mouth of the river which Campbell called the Lewes. Here was a large camp of "Wood Indians," and these, after recovering from their surprise at the sight of the party, so discouraged Campbell's men by their stories of the number and ferocity of the people on the lower river, that he was obliged to turn back.

For some years afterwards the operations of the Company did not extend beyond "Pelly Banks," though during the summer, hunting "Pelly Banks."

parties were sent down the Pelly to collect provisions, and in that way information was received respecting the river and the Indians inhabiting its vicinity.

Establishment of Fort Selkirk.

In the winter of 1847-48 boats were built at Pelly Banks, and early in June following Campbell set out to establish a fort at the confluence of the Pelly and Lewes rivers. This was named Fort Selkirk, and was at first situated on the extreme point of land between the two rivers, but this point being found subject to floods during the disruption of the ice, the post was in the spring of 1852 moved to a site a short way below the mouth of the Lewes, on the left bank. The inner work of the new buildings was still unfinished at the time of the Indian raid, noticed further on.

Exploration of Porcupine River.

Meanwhile an entry was being made into the Yukon basin from another direction. Mr. J. Bell had already in 1842 reached the Porcupine or Rat River, and had descended it for three days' journey. He was in 1846 in charge of the Hudson Bay post on Peel River, near the mouth of the Mackenzie, and was instructed again to cross the mountains and to further explore the Porcupine River. In pursuance of these instructions, he in that year reached the mouth of the Porcupine and saw the great river into which it flows, which the Indians informed him was named the Yukon. In 1847 Fort Yukon was established at the mouth of the Porcupine by Mr. A. H. Murray.

Identity of Pelly and Yukon shown.

It still remained, however, for Campbell, in 1850, to prove that the Pelly and Yukon were identical. This he did by descending the river from Fort Selkirk, to Fort Yukon, after which he ascended the Porcupine, crossed the mountain-portage, and returned to Fort Simpson by the Mackenzie.* One result of this journey was to show that the route from Fort Selkirk by way of the Porcupine River to the Mackenzie was preferable to that originally discovered. The navigation of the Liard was both arduous and dangerous and several lives had been lost in boating on that stream. Added to this was the length of the land transport from Frances Lake to the Upper Pelly and the fact that great difficulty had been found in maintaining the posts in that district.

* Mr. Campbell states that when again on his way down the river from Fort Selkirk to Fort Yukon, in 1851, he found that a great number of the Indians had been carried off during the previous winter by some virulent disease.

He has further informed me, in answer to my enquiries on the subject, that the Stewart River was so named after his "dear and gallant friend and assistant-clerk, James G. Stewart, son of the late Hon. John Stewart, of Quebec." Stewart was sent out in the winter of 1849 to follow the Indian hunters in quest of meat. He found them some distance north of this river, which he crossed on the ice.

White River, Mr. Campbell named on account of its milky color. Of the other streams entering between Forts Selkirk and Yukon he says, "Antoine River" was named after the interpreter at one time at Fort Yukon, a son of his interpreter Hoole; "Forcier River," after his guide, Baptiste Forcier; "Lolique River," for Forcier's wife; and "Ayonie's River," below the White River, was named after the natives of that quarter.

Abandonment of posts.

In 1849, the post at Pelly Banks, with the exception of the men's house, was accidently burnt. In 1850 it was finally abandoned, and in the spring of 1851 Fort Frances was likewise abandoned.* The abandonment of these posts was not due to any hostility of the natives, who were on the contrary most friendly, but in consequence of the circumstances above noted, and the fact that while these establishments were very expensive to maintain, they merely bought furs which would otherwise have been carried by the Indians themselves to other posts, if these particular, and to them more convenient ones, had not been in existence.

Irruption of the Chilkoots.

The several ruined chimneys of Fort Selkirk still to be seen, with other traces on the ground, are in themselves evidence of the important dimensions and careful construction of this post. The establishment consisted, I believe, in 1852, of one senior and one junior clerk and eight men. The existence of this post in the centre of the inland or "Wood Indian" country had, however, very seriously interfered with a lucrative and usurious trade which the Chilkoot and Chilkat Indians of Lynn Canal, on the coast, had long been accustomed to carry on with these people; acting as intermediaries between them and the white traders on the Pacific and holding the passes at the head-waters of the Lewes with all the spirit of robber barons of old. In 1852, rumours were current that these people meditated a raid upon the post, in consequence of which the friendly local Indians staid by it nearly all summer, of their own accord. It so happened, however, that they absented themselves for a couple of days and at that unlucky moment the Coast Indians arrived. The post was unguarded by a stockade and yielding to sheer force of numbers the occupants were expelled and the place was pillaged, on the 21st August. Two days afterward Campbell, having found the local Indians, returned with them and surrounded the post, but the robbers had flown. Being now without means of support for the winter, Campbell set off down stream to meet Mr. Stewart and the men who were on the way back from Fort Yukon. He met them at the mouth of White River and after turning them back with instructions to arrange for wintering at Fort Yukon, set out himself in a small canoe up the Pelly River, crossed to Frances Lake, descended the Liard and arrived at Fort Simpson with the tidings of the disaster, amid drifting ice, on the 21st of October.

Campbell's journey of 1852.

Being anxious to obtain Sir George Simpson's permission to re-establish Fort Selkirk, Campbell waited only till the river froze, when he left Fort Simpson on snow-shoes and travelled overland to Crow Wing in Minnesota, where he arrived on the 13th of March. On the

* Forts Frances and Pelly Banks are erroneously stated in Dall's Alaska and its Resources, to have been burnt and pillaged, p. 115, foot-note and p. 508.

18th of April he reached London but was unable to obtain from the directors of the company the permission he desired. A short account of this remarkable journey appeared in the Perthshire Advertiser and Inverness Courier, but I do not know the precise date of the publication.

News from Fort Selkirk.

In the autumn of 1853, one of Campbell's hunters arrived at Fort Halkett on the Lower Liard by way of the Pelly and Frances. This is the last traverse of Campbell's Portage of which I can find any record, though it may doubtless have been used by the Indians subsequently. From this man it was learnt that the buildings at Fort Selkirk had been all but demolished by the local Indians for the purpose of getting the iron-work and the nails. He also stated that the Chilkats, being unable to carry away all their plunder in the preceding year, had taken merely the guns, powder and tobacco. They had câched the heavier goods, which were afterwards found and appropriated by the local or wood Indians. At a later date the ruins of the post must have been burnt, as their present appearance indicates.*

The United States and Fort Yukon.

Fort Yukon, at the mouth of the Porcupine, was continuously maintained till 1869, when the Hudson Bay Company was expelled by the United States Government as represented by Capt. Charles W. Raymond, Corps of Engineers, U. S. Army; he having ascertained by astronomical observations that the post was situated to the west of the 141st meridian. He describes his proceedings as follows.—"On the 9th of August, at 12 m., I notified the representative of the Hudson Bay Company that the station is in the territory of the United States; that the introduction of trading goods, or any trade by foreigners with the natives, is illegal, and must cease; and that the Hudson Bay Company must vacate the buildings as soon as practicable. I then took possession of the buildings and raised the flag of the United States over the fort." † The fort was afterwards abandoned and allowed to go to ruin.

Pioneers of the Hudson Bay Company.

The utmost credit must be accorded to the pioneers of the Hudson Bay Company for the enterprise displayed by them in carrying their trade into the Yukon basin in the face of difficulties so great and at such an immense distance from their base of supplies. To explorations of this kind performed in the service of commerce, unostentatiously and as matters of simple duty by such men as Mackenzie, Fraser, Thompson and Campbell, we owe the discovery of our great north-west country. Their journeys were not marked by incidents of conflict or bloodshed, but were accomplished on the contrary with the

* Of Reid House, shown on Arrowsmith's map of 1854, near the Stewart River and to the north of Fort Selkirk, I have been unable to learn anything. Mr. Campbell never heard of it, and if it had any existence it was probably a temporary outpost of Fort Yukon.

† Report of a Reconnaissance of the Yukon River, 1871, p. 16.

friendly assistance and co-operation of the natives. Less resolute men would scarcely have entertained the idea of utilizing, as an avenue of trade, a river so perilous of navigation as the Liard had proved to be when explored. So long, however, as this appeared to be the most practicable route to the country beyond the mountains, its abandonment was not even contemplated. Neither distance nor danger appear to have been taken into account, and in spite of every obstacle a way was opened and a series of posts established extending from Fort Simpson, on the Mackenzie to Fort Yukon. Fort Simpson may itself be regarded, even at the present day, as a post very far removed from the borders of civilization, but this further route, which nearly half a century ago became familiar to the Company's voyageurs, stretched out beyond it for over a thousand miles. Mr. James Anderson, in 1853, writes thus of the Liard River: "You can hardly conceive the intense horror the men have to go up to Frances Lake. They invariably on re-hiring endeavour to be exempted from the West Branch [Liard]. The number of deaths which have occurred there is fourteen, viz. three in connection with Dease Lake and eleven in connection with Frances Lake and Pelly Banks, of these last three died from starvation and eight from drowning." Dangers of the Liard.

At the time of the establishment of Forts Yukon and Selkirk, and for many years afterwards, the "returns" from these furthest stations reached the market only after seven years, the course of trade being as follows: *Goods.*—1st year, reach York Factory; 2nd year, Norway House; 3rd year, Peel River, and were hauled during the winter across the mountains to La Pierre's House, 4th year, reach Fort Yukon. *Returns.*—5th year, reach La Pierre's House and are hauled across to Peel River; 6th year, reach depot at Fort Simpson; 7th year reach market. The "returns."

LEWES RIVER.

Our proceedings at the mouth of Lewes River and our meeting there with Mr. Ogilvie have already been noted. We finally left the confluence and began the ascent of the Lewes on the 18th of August, and arrived at Lake Lindeman, where the portage to the coast begins, on September 16th. We were during this time on the one travelled route of the country, and every few days fell in with small parties of miners, generally on their way out, up the river. A few men were still found working on bars, and six or eight passed down stream with the purpose of wintering at or near Forty-mile Creek. Meeting with Mr. Ogilvie.

Though my own observations did not extend below the mouth of the Lewes, Mr. W. Ogilvie sent out by the last party of miners met by

him on their way to the coast, a small collection of rocks from places further down the river, as far as Forty-mile Creek. The general character of these has already been noted in the introductory part of this report (p. 34 B). They are not further described here, as they will be referred to by Mr. McConnell in connection with his geological examination of the portion of the river from which they were derived.

Discovery of the Lewes.

The Lewes River * was discovered and named by Mr. Campbell in 1842, as already stated. It is indicated in an approximate manner, according to information supplied by this gentleman, on Arrowsmith's map of 1854. Mr. Campbell informs me that he was well aware of the existence at its head of a portage to the sea by which the Chilkat Indians came inland to trade. This route he had the intention of exploring, but the question of supplies and other difficulties prevented him from doing so. Communication was occasionally had by this route with the Hudson Bay steamer which traded along the coast, and it was thus that the Honolulu paper mentioned as received in 1848 by Sir. J. Richardson, on the Mackenzie, was sent inland. Such communication was, however, only accomplished by travelling parties of Indians.

First exploration.

In 1867, Frank E. Ketchum, of St. John, New Brunswick, and Michael Labarge, of Montreal, explorers in the employ of the Western Union Telegraph Company, ascended the Pelly or Yukon from Fort Yukon to the mouth of the Lewes, returning down the river. In the same year, Michael Byrnes, also an explorer of the Telegraph Company, reached the Hotolinqu (of Telegraph Survey map, not the river subsequently so called by miners) which is now known to be one of the furthest if not the most remote source of the Lewes. This he did from the direction of the Stikine, but was recalled before he had, by descending the river, proved its relation to the Lewes. †

Incursion of miners.

As elsewhere stated, in connection with the history of gold mining in the Yukon basin, (p. 178 B) the head-waters of the Lewes River were first reached from the head of Lynn Canal about 1878. Between the date of the explorations of the Telegraph Company and this time, the Lewes may have been visited by traders ascending from the Lower Yukon, but of this we have no record. Previous to 1883, however, the river and some of its tributaries had become well known to a number

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* So named by Campbell after Chief Factor, John Lee Lewes.
The name of the Lewes given to me by the Tagish Indians was Ta-hi-ne-wat (=Big Salmon River) but I am doubtful whether this applies to the whole stream or to some special part of it.

† See Dall's Alaska, p. 277. A statement in a subsequent paragraph on the same page would appear to indicate that Messrs. Ketchum and Labarge reached Lake Labarge of later maps, but I can find nothing to bear this out. Whymper, in his travels in Alaska and on the Yukon (p. 229) also limits their journey at Fort Selkirk. Dall in consequence of the imperfection of the map of the Telegraph Survey with which he was supplied, in his work and on the map accompanying it, continues the head-waters of the Taku River into the Hotolinqu River, making them tributary to the Lewes, but in an addendum, at the end of the book, notes and corrects this error.

of miners and prospectors, and when Lieut. Schwatka, in the last mentioned year, crossed the Chilkoot Pass and descended the Lewes, he merely followed in their footsteps. To Lieut. Schwatka is, however, due the credit of having made the first survey of the river, a survey which Mr. Ogilvie's work of 1887, has proved to be a reasonably accurate one, in so far as its main features are concerned. This being the case it would be an ungracious task to criticise in detail, either Lieut. Schwatka's map or the various accounts which he has given of his journey. As, however, he is not sparing in his condemnation of the inaccuracy of the compilers of the maps made before the results of his journey were available, I need have no hesitatión in stating my belief, that his desire to affirm that he had started at the source of the Yukon and followed it to its mouth, caused him to fail to observe that Lake Lindeman is not even on the main source of the Lewes, and to change the name of the Lewes which had already appeared on the maps for about thirty years to that of Yukon, a quite arbitrary and unjustifiable proceeding. (See p. 16 B.) In addition to this he has completely ignored the names of many places already well known to miners, throughout the country, substituting others of his own invention, some of which even differ in the different versions of the map of his route which he has published. Strict justice might demand the exclusion of all these new names on the definitive maps now published, but to avoid an appearance of arbitrary action in the matter, and more especially in view of the scientific eminence of some of the names which he has selected, it has been decided to retain as many as possible of these. **Surveys by Schwatka.**

While the general course of the Upper Pelly is remarkably straight, that of the Lewes makes several important and well marked bends and is besides interrupted by lakes and otherwise irregular. These irregularities are to be accounted for by the fact that the Lewes, instead of following a direction parallel with the main orographic features of the country, runs for a considerable part of its course diagonally across the principal ridges and valleys. **Pelly and Lewes contrasted.**

In describing the Lewes and the main geological features met with along it, the site of Fort Selkirk is taken as an initial point and the distances are given as measured on the map, up the mid-channel of the river. The distances thus arrived at will not be found to correspond exactly with those given by Mr. Ogilvie in his preliminary account of his survey of the river,* Mr. Ogilvie's distances being those instrumentally measured from station to station of his survey. **Distances.**

* Contained in the Annual Report of the Department of the Interior for 1887. See also Report of Proceedings of Association of Dominion Land Surveyors, 1883, p. 61.

Fort Selkirk to Rink Rapid.

Character of the river.

From the site of Fort Selkirk to Rink or Five-finger Rapid, the course of the river is nearly straight, the bearing being about S. 50° W. and the distance, measured by the stream, fifty-five miles. The current of this part of the river is swift throughout, averaging about four miles and a-half an hour and seldom being under four miles. At a point six miles below Rink Rapid, where the course of the river was uninterrupted by islands and its velocity and width about normal, the rate of flow was found to be 4·8 miles per hour, the width 732 feet. There are numerous islands, which differ from most of those met with on the Pelly in frequently occupying positions in mid-channel instead of being merely portions of river-flats cut off by lateral sloughs. A few miles above the mouth of the Lewes, these islands are particularly numerous, for a distance of about five miles, and the total width of the stream from bank to bank, is increased to nearly a mile. This group has been named Ingersoll Islands by Schwatka.

Terraces.

The terraces and flats immediately bordering the river, are at first quite low, but in ascending, increase in height till they stand often at 100 to 200 feet above it before reaching Rink Rapid. They are for the most part composed of rolled river- or valley-gravels like those of the Pelly at a similar distance above the confluence. Boulder-clay first occurs in the scarped banks about six miles below Rink Rapid.

Character of the valley.

The river-valley is generally wide and somewhat ill defined, the ridges and low hills bounding it seldom exceeding 1000 feet in height. Near the mouth of the river these are irregularly disposed, but further up, those on the north-east bank become more uniform and run parallel to the stream like the hills on that part of the Pelly near the Macmillan. In a few places the slopes of the hills run down to the water's edge, and it is generally only at such points that rock exposures occur. Hoo-che-koo Bluff is situated thirty-five miles above the old fort, on the north-east bank, and is formed by the abrupt face of an isolated hill, against which the river washes. With the exception of Tatshun River, a mile and a-half below Rink Rapid, the tributaries of this part of the Lewes are merely small brooks. This stream is about 30 feet wide by 6 inches deep, with clear brownish water.

Rink Rapid.

Two miles below Rink Rapid, the Lewes makes a right-angled bend to the south-westward. The rapid itself is caused by the occurrence of several bold rocky islands which obstruct the river, and is only a few yards in length, where the water flows swiftly between them. The channels are deep and unobstructed, and at low stages of water might, I believe, be ascended by a steamer of good power even without the assistance of warping. At high-water this rapid would, of course, be

more formidable, as the velocity of the stream would be increased. It is pretty evident that a fall has at one time existed here, but the barrier of conglomerate which has produced it has now been cut completely through by the river. Below the main rapid there is a second "riffle" or minor rapid which appears to be somewhat stony, but which would not be a serious impediment to a properly constructed steamer.

Fine country. The general appearance of the country along this part of the river is pleasing and resembles that of the corresponding part of the Pelly. It is usually wooded, but the southern exposures of some of the hills are partly open, and dry, grass-covered terrace-flats are frequent. The trees are of the same species before mentioned and birch is moderately abundant. *Elæagnus argentea* was noted on dry banks.

Geology. On this part of the Lewes, rock-exposures are unfrequent and it is consequently impossible to give any connected account of the geology. About five miles above the old fort, on the west bank, are outcrops of basalt, which appear to indicate an outlying patch of this rock. Just below these on the river, is a dark greenish rock which seems to be a bedded diorite and to have a high south-west dip. On the other side of the basalt, a massive, coarsely crystalline, black, hornblende-rock occurs, which is followed by hornblendic granite. The granite, in some places, contains large porphyritic crystals of pink felspar, in addition to the more abundant white triclinic felspars. It continues for some miles, near the Ingersoll Islands, and probably connects with the exposures on the Pelly to the north-east. The few exposures examined between the granite and Hoo-che-koo Bluff, consist of greenish and greenish-grey rocks, being altered volcanic materials, probably with the lithological composition of diabase. In one place a distinct volcanic agglomerate was seen.

Hoo-chee-koo Bluff. Hoo-chee-koo Bluff consists of a grey, slightly porphyritic, felspathic rock which is apparently interbedded with a fine-grained, nearly black argillite, but the rocks are everywhere very much fractured and jointed. The south end of the bluff shows a pretty evident, altered agglomerate of a similar felspathic material. The jointage planes often contain seams of calcite and show copper-staining. Specimens of the copper-stained portions of the rock proved, on assay by Mr. Hoffmann, to contain minute traces of gold, with ·088 oz. of silver to the ton.

The rocks along the Lewes so far described, with the exception of the granites, may be referred to the Palæozoic.

Rocks above Hoo-chee-koo. For about twelve miles above the Hoo-chee-koo Bluff no rocks were seen, after which, for eight miles, or to Rink Rapid, there are frequent exposures of rocks of a different series, of much less altered appearance and all probably referable to the Cretaceous. These include coarse, hard, dark grauwacke-sandstones, with softer shaly sandstones, passing

Cretaceous rocks.

into dark sandy shales, all more or less calcareous. Just below Rink Rapid, on the south-east bank, are brownish evidently tufaceous rocks, the materials of which also, however, include well-rounded quartz pebbles. These pass by easy stages into grauwacke-sandstones and are interbedded with coarse conglomerates containing pebbles of granite and of greenish altered volcanic rocks, like those of the older series seen lower down the river. Carbonaceous streaks and pieces of dark-coloured fossil wood are included in some of the beds; and a couple of layers two to three feet thick, were observed, which are so carbonaceous that they might almost be called coal. The dip is here N. 20°, W. $< 40°$, but elsewhere in this vicinity is varied and confused.

Conglomerates and sandstones.

The rock of the islands and banks of the actual rapid is coarse conglomerate which often contains boulders of granite up to eighteen inches in diameter and is interstratified with irregular beds of yellowish sandstone, the appearance of the conglomerate being much like that of the conglomerate of Jackass Mountain on the Fraser River, though somewhat less altered. Immediately above the rapid, on the south-east side of the river, grey and blackish shales, with thin beds of sandstone and of limestone, appear from below the conglomerates. These were found to contain fossils in considerable abundance, though representing but a few species.

Cretaceous fossils.

The fossils have been examined by Mr. Whiteaves, who states that of four determinable species, all but one appear to be new, but that the occurrence of a *Schlœnbachia* apparently identical with a species from the lower part of the section in the Queen Charlotte Islands, would seem to show that the rocks may be of corresponding age, or about the lower part of the Middle Cretaceous.

The species are as follows:—*

Discina pileolus, N. sp.
Cyprina Yukonensis, N. sp.
Schlœnbachia (*propinqua?* var.) *borealis*.
Estheria bellula, N. sp.

Fossil plants.

Sir J. Wm. Dawson has examined the fossil woods found at the same place, and writes of them as follows:—"Two species of fossil coniferous wood. One of these shows large wood-cells with one to two rows of discs and long narrow medullary rays. It is not improbably the wood of a species of *Sequoia*. The other has thick-walled wood-cells with one row of discs and spiral lines, the medullery rays being short and few celled. It has the characters of a taxine wood, and is not unlike that of *Salisburia*. Another specimen from this place is a small and badly preserved branchlet, with short and apparently thick curved

* To be described and figured in Part II. Contributions to Canadian Palæontology.

subulate leaves. It is probably coniferous, and it is not unlike *Sequoia ambigua* and *S. concinna*, of Heer, from the Cretaceous of Greenland. It is, however, quite obscure, and might be a species of the Mesozoic genus *Pachyhyllum*."

Gravels of the Lewes. The constituents of the gravel found along the Lewes River differ considerably in appearance from those of the Pelly gravels. Granite of various kinds is abundant, and there is a notable profusion and variety of green and greyish-green altered rocks of volcanic origin in association with which are found occasional pebbles of more or less pure jade, which appear to pass by insensible gradations into green rocks of the kind above mentioned. Quartz vein-stuff is much less important as a constituent of the river-gravels than it is on the Upper Pelly, Upper Liard and other streams to the eastward.

Rink Rapid to Little Salmon River.

From Rink Rapid to the mouth of the Nordenskiöld, the general bearing of the river is nearly due south, the distance in a straight line being twelve miles. From this point the general bearing is about south-east for eighteen miles and a-half, when it turns abruptly to a north-east direction round Eagle's Nest Rock, and in five miles reaches the mouth of the Little Salmon River. The total distance from Rink Rapid to the last-named place, measured by the stream, is fifty-three miles, though the through distance, on a straight line (which would have a south-east bearing) drawn between the two terminal points is twenty-seven and a-half miles only.

Nordenskiöld River. The Nordenskiöld is a small swift river with clear bluish water, which enters the Lewes on the west side. It was estimated as eighty feet wide by six inches deep, a couple of hundred yards above its mouth, on the 23rd of August, when it was evidently near its lowest stage. Its valley is not a wide or important one, it being in fact difficult to decide from which direction the stream comes a few miles back from the Lewes. The Little Salmon (or Daly, as re-christened by Schwatka) joins the Lewes on the opposite side, and was estimated to carry about twice as much water as the Nordenskiöld. It is about one hundred feet wide with an average depth of three feet. The water is clear and brownish in tint, and the current not rapid at the mouth.

Lewes valley. The valley of the Lewes, between Rink Rapid and the Little Salmon River, is in general somewhat irregular and not very wide, but a few miles before reaching the Little Salmon, the river turns into a wide valley which runs north-east and south-west and appears to be continuous with that of the Little Salmon in the first mentioned direction. The hills, in the vicinity of the river, seldom exceed 800 feet in height, till near the Little Salmon, when they attain 1000 or possibly 1500 feet.

No mountains are in sight from this part of the river. Terraces rising to 200 feet are frequent and often run back at about that level to the bases of the hills. Near the mouth of the Nordenskiöld, the river is extremely crooked, and the current is everywhere swift. The southern slopes of the hills and terraces are generally in large part open and grassy, no difference such as might indicate a climate more humid than that of the region about old Fort Selkirk being met with. Several magpies were seen, for the first time, on this part of the river.

Gold bars. The first spot observed by us in ascending the river where bars have been worked for gold, is situated six miles above the Nordenskiöld.

Thick Cretaceous series. The rocks along this portion of the river, like those last described, belong to the Cretaceous series, but their attitudes are too varied to enable anything like a complete section to be gained from the isolated exposures met with, though the impression was received that the total thickness represented must be very great. The rocks consist generally of sandstones, grauwackes, coarse grits and conglomerate which not unfrequently have a general reddish appearance on weathering, probably in consequence of local dolomitization. A few localities, however, show features worthy of special mention.

Beds of coal. One of these is found five miles and a-half above Rink Rapid, where a high bluff shows a series principally composed of sandstones, shales and shaly clays, poorly exposed in consequence of the sliding character of the bank, which is being washed away by the river at its base. These have a south-eastward dip, at low angles, and the thickness of beds represented must be several hundred feet. This exposure includes, within sixty feet of the base of the bluff, at least three coaly beds, of which the lowest is about three feet thick. This and the other beds contain some good looking coal, of which a thickness of about a foot sometimes occurs, but the greater part of the material is so sandy and impure as to be useless. The highest of these beds is underlain by a layer of dull purplish-grey, finely granular and porphyritic trachyte from six to eight feet in thickness, and evidently representing a contemporaneous flow of volcanic matter. Its upper surface is somewhat broken up and mixed with carbonaceous matter, and passes into black, carbonaceous sandstone, about a foot thick, above which is the upper impure coal before referred to, overlain by shales and sandstones of the ordinary character.

Wide synclinal The condition of all the beds in this vicinity is remarkably unaltered, as compared with those seen lower down the river, and would appear to show that if (as assumed) they form a connected series, these represent its upper part. The dip of these beds, taken in connection with that of those near Tantalus Butte and the horizontal appearance of the strata in the hills to the south-westward, indicates the existence

of a synclinal five or six miles in width, running in a south-west by north-east direction. The relatively high position of these beds is further shown by the occurrence, about two miles further up the river, of fossil plants referable to the Laramie. These were found in a hard, white, shaly rock, which has apparently been permeated by waters charged with silica about the time of its formation. Sir J. Wm. Dawson states that the following species are represented:— **Fossil plants.**

Taxodium Tinajorum, Heer.
Glyptostrobus Europæus, Heer.
Sequoia Langsdorffi, Heer (doubtful).

The thin coal-seams here actually seen cannot be considered as of economic value, but are important as indicating the existence of a coal-bearing horizon which may prove to contain thicker beds elsewhere and might become an important point in connection with the navigation of the river. The coal has been examined by Mr. G. C. Hoffmann who describes it as a lignite-coal, with the following composition.— **Composition of coal.**

Hygroscopic water	6·03
Volatile combustible matter	36·92
Fixed Carbon	49·03
Ash	8·02
	100·00

About a mile below Eagle's Nest Rock, are exposures of coarse conglomerate, with inter-bedded sandstones precisely like those of Rink Rapid. The included stones are well rounded, and often a foot in diameter, and consist of granites and various green and grey hard, altered, volcanic rocks. This is probably the same conglomerate bed with that of the rapid. The dip here is N. 13° W. $< 40°$. **Conglomerate.**

Frequent exposures of true boulder-clay occur along this part of the river, particularly above the Nordenskiöld, where they often form castellated bluffs, in consequence of their considerable induration. The boulder-clay generally shows traces of bedding more or less distinct, and is sometimes very stony and includes large boulders, a few of which were observed to be striated. The pebbles are, as a rule, well rounded and even superficially polished. Clayey gravels with silty layers are in places associated with the boulder-clay in the manner already described on the Pelly. In some places the boulder-clay also appears to be overlain by silty deposits, but on the Lewes thus far up, these are not extensive or well marked. **Drift deposits.**

Little Salmon to Big Salmon River.

The river and its valley.

From the Little Salmon to the mouth of the Big Salmon River or D'Abbadie, the general bearing of the Lewes is about east-south-east, and the sinuosities of the river are not nearly so great as in the portion last described. The distance by the stream between these tributaries is thirty-four miles. A considerable portion of this part of the river is not so swift as usual, and for eight or ten miles, midway between the Little and Big Salmon rivers, both the river and its valley are more than usually narrowed. Beyond this, the valley begins to widen rapidly and for some miles before the mouth of the Big Salmon is reached, is notably wide, between the bases of the limiting hills. At the mouth of the Big Salmon, the Lewes turns abruptly to the south, while the main valley is continued in a south-easterly direction, becoming there the valley of the Big Salmon. From the confluence of the rivers, the main valley can be seen running on for a distance of about fifteen miles, bordered by low hills to the northward, and by higher hills to the south. These last are the Seminow Mountains of Schwatka. The Lewes cuts through this range, which is continued also for some miles westward, forming the south-west side of the Lewes valley. The hills are rounded in form and wooded, and rise to heights of 1500 to 2000 feet above the river.

Geological features.

Few rock-exposures occur along this part of the Lewes, and in consequence, nothing very definite can be said as to its geological structure. Thirteen miles above the Little Salmon, greenish, grauwacke-sandstones, and green, highly calcareous conglomerates were found, the latter containing pebbles of limestone or marble, granite, various schistose rocks and green altered volcanic rocks. The greater part of the hills in this vicinity seemed to be composed of similar materials, which are evidently newer than the altered volcanic series, and therefore in all probability Mesozoic, and very possibly even Cretaceous. For some distance below the Big Salmon, numerous fragments of lignite-coal and of soft, shaly materials, like those previously described as occurring with the coal, are found on the bars, but cease to appear above the confluence of the Big Salmon, leading to the belief that Cretaceous or Laramie rocks attain a considerable development in the valley of that stream. It would require, however, a detailed survey to separate the various formations in this region, and the result of such an examination would probably be to place in the Mesozoic series a much larger area than would, at first sight, appear probable. At the mouth of the Big Salmon a grey-green, crystalline rock which is apparently a diorite, occurs. It appears to be bedded, and dips southward at an angle of 25°.

Nine miles below the Big Salmon is the first extensive display met with on the Lewes of the bedded silty deposits. Scarped banks and cliffs one hundred feet in height are here composed of these white silts with some interstratified sands and gravels. The silts contain numerous nodular layers and sheets of calcareous concretionary matter, and are hard and fine-grained toward the base, where they may be seen, in some places, resting on boulder-clay. Bedded silts.

Several bars which had been worked on for gold were seen along this part of the Lewes. Gold.

Big Salmon River.

The Big Salmon* has been re-named by Schwatka, the D'Abbadie River, a name which has the merit of being more distinctive than that previously in use, but the miners who (with the exception of the Indians) alone travel through the country, refuse to know it by any but the old name. It is much more important than any of the tributaries joining the Lewes further down, being 347 feet wide, with a depth of five feet for about one-third of its width, and a current of about two miles an hour. The water is clear and of a bluer tint than that of the Little Salmon, and the discharge was estimated at 2726 cubic feet per second, when probably rather below its mean stage. It might, no doubt, be navigated by a small stern-wheel steamer for many miles. Appearance of the river.

I was afterward so fortunate as to meet a party of four miners who had spent a part of the summer of 1887 in prospecting this stream, and from one of them, Mr. John McCormack, obtained some particulars respecting it, together with a sketch of its course. Thirty-two miles from the Lewes, the Big Salmon is said to be joined by a smaller stream, which McCormack calls the North Fork. For about a mile and a-half below, and a short distance above the mouth of this branch, the river is very rocky and rapid. Half a mile above it there is an Indian salmon-fishing place. For some distance beyond this the river is sluggish, and at sixty-six miles from the Lewes, the South Fork branches off. This fork occupies a wide valley and comes from the south-eastward. Above it the water is swifter and the valley of the river is narrow. with high mountains on both sides, but particularly on the north. Granite and mica-schist were seen along this part of the river. At a supposed distance of one hundred and five miles from the Lewes, another stream joins from the south-east, and this also occupies an important valley, though not so wide as that of the South Fork. Above this point the river turns to a northerly bearing for about fifteen miles, the current being, in general, slack. It then reverts to an easterly bearing, and Notes on upper part of river.

* Ta-tlin-hi-ni of the Tagish.

Lakes at head of river.

after passing a rapid, at one place, Island Lake is reached at 190 miles from the Lewes. This lake is four miles long, and has two arms at its upper end, from the southern of which a river leads, in eight miles, to a second lake two miles and a-half long. A stretch of river, a mile and a-half long, joins this to the highest lake, which McCormack named Quiet Lake, and of which he estimates the length at twenty-four miles. At the outlet of the lake is an Indian fishing place. The country to the south of these lakes is mountainous, granite being a common rock, and several streams run from these mountains into Quiet Lake. The north-east side of the lake is bordered by lower ridges, and from its head, McCormack travelled about eight miles, through a low country, to the bank of the Tes-lin-too, which he found here flowing from north to south.*

Gold.

These miners found "fine" gold all along the river, but no good paying bars. They were in search of "coarse" gold, but did not discover any. A small specimen of pyrites and quartz, from veins met with on one of the streams flowing into Quiet Lake, given to me by Mr. McCormack, was found by Mr. Hoffmann to contain very distinct traces of gold with a trace of silver.

Salmon.

According to the Indians, the salmon run up this river to its source, and the same is reported of the Little Salmon and the Tes-lin-too.

Big Salmon River to Tes-lin-too.

The river and river-valley.

As already noted, the bearing of the Lewes becomes nearly due south, at the mouth of the Big Salmon. Though crooked in detail, it preserves this general bearing to the mouth of the Tes-lin-too, a distance by the river of thirty-one miles. Both the valley and the river itself are unusually narrow where the Seminow Hills are cut through, the width of the range being about five miles, and the river continues narrow and deep, with a swift current, beyond this point, though, the valley widens and permits the stream to resume its flexuous character. The actual width of the river, at a point nine miles below the mouth of the Tes-lin-too, was ascertained to be 483 feet, the current being at the rate of 4·84 miles per hour. These figures may be taken as representing the general character of this part of the stream. A short distance south of this point, the river again begins to widen and to resume its usual aspect. The hills bounding the valley on the south of the Seminow range seldom exceed a height of 800 feet till the vicinity of the confluence of the Tes-lin-too and Lewes is reached, when they gradually increase to 1000 or 1500 feet.

* The above estimates of distance are probably all in excess, and include the minor sinuosities of the stream. The actual distances from point to point are shown on the map as well as it has been possible to estimate them.

A number of auriferous gravel-bars have been worked along this part of the Lewes, including Cassiar Bar, which has so far proved the richest on the river. Limited areas of the river-flats have also been worked over, where the alluvial cover is not too deep. Cassiar bar.

The valley near the mouth of the Tes-lin-too is again narrower than usual, singularly so for the point of confluence of two important rivers. The valley of the Tes-lin-too is evidently the main orographic depression which continues that occupied by the Lewes below the confluence. The Lewes flows in through a narrow gap, closely bordered by high hills and nearly at right angles to the lower course of the river. On the map accompanying Lieut. Schwatka's report, the width of the Tes-lin-too is shown as about half that of the Lewes, the actual fact being precisely the reverse and all the main features of the lower river being contained by the Tes-lin-too; while the other branch, both in its irregular mode of entry, the nature of its banks, the colour of its water and its very rapid current, presents, at first sight, all the appearance of a tributary stream of new character. To such an extent is this difference observable, that Mr. Ogilvie and the members of his party, as well as most of the miners on the river, were of the opinion that the Tes-lin-too actually carries much the greater volume of water. As this appeared to be a question of some importance, we stopped a day at the confluence for the purpose of investigating it, cross-sectioning each river and ascertaining the rate of the current at distances of about half a mile from the junction, where the circumstances were favourable. It was thus ascertained that the rivers possess the following dimensions:— Lewes and Tes-lin-too compared. Volumes of rivers.

	LEWES.	TES-LIN-TOO.
Mean width....................	420 feet.	575 feet.
Maximum depth (near left bank)	12 " (near right bank)	18 feet 4 inches.
Sectional area..................	3015 "	3809 feet.
Maximum velocity..............	5·68 miles pr. hr.	2·88 miles pr. hr.
Discharge per second...........	18,664 cubic feet.	11,436 cubic feet.

In connection with these measurements it may be stated that the Lewes showed evidence of having risen about a foot above its lowest summer level, while the Tes-lin-too was probably near its lowest summer stage.* If we subtract the volume of water represented by this extra foot in depth, the discharge of the Lewes at the summer low-water stage may be approximately stated at 15,600 cubic feet. The water of the Lewes has a blue, slightly opalescent colour, much resembling that of the Rhone where it issues from the Lake of Geneva, while that of the Tes-lin-too is brownish and somewhat turbid. The temperatures of the Lewes and Tes-lin-too were respectively 54° and 53·5° F. on the evening Water of the two rivers.

* All the rivers in this country reach their actual minimum toward the end of the winter.

of August 31st. A considerable part of the water of the former stream must be derived from the glaciers and snows of the Coast Ranges, but the existence of large lakes on both streams doubtless accounts for their proximate equality in temperature.

Rocks.

From the few exposures which occur on that part of the Lewes which cuts across the Seminow Hills, the range would appear to be composed of greenish, altered volcanic rocks, probably diabase, interbedded with grey or whitish marble. Rocks of this character are those which have supplied the material for the conglomerates described before (p. 146 B) and are evidently much older than these and doubtless referable to the Palæozoic. At another place, south of the Seminow Hills, felsite, schistose diabase and dark fractured argillite were noted in association, and at about a mile and a-half below the Tes-lin-too, purplish and greenish amygdaloid, with calcareous filling, was seen. The exposures on this part of the river are few and unconnected and that last mentioned shows less sign of alteration than usual, and may be referable to a period newer than the Palæozoic.

Drift deposits.

Clayey and earthy gravels, like those often associated with the boulder-clay, were noted in some places along this part of the Lewes. These are overlain by nearly white, bedded silts, which often form entire banks of considerable height. A mile and a-half below the mouth of the Tes-lin-too, the first glaciated rock-surfaces seen in ascending the Lewes, were noted. The direction of glaciation is N. 4°, E. The glaciation is here well preserved on surfaces a few feet above the river, and consists of wide, shallow, straight grooves and flutings, quite evidently the work of a glacier.

Tes-lin-too or Newberry River.

Notes on the river.

The Tes-lin-too River is named the Newberry or Tess-el-heena* on Schwatka's map, and is evidently the same which is sketched on the U. S. Coast Survey map of Alaska, etc., (1884) as the Nas-a-thane. By the miners who pass along the Lewes, it is known as the Hootalinkwa or Hotalinqu, in consequence, as it proves, of a misapprehension. The Hotilinqu, which has appeared on the maps for many years, was traversed in its upper part by Byrnes in the course of his exploration already mentioned. I have ascertained that one or more of the miners who first descended the Lewes knew Byrnes and were familiar with his work, and, naturally enough, on finding this

* This is doubtless a version of Tes-lin-hī-nī, *hīn* (or in combination *hī-nī*) being Tagish for river. Tes-lin-too is the name given to me by the Tagish Indians, the termination being the Tinné equivalent for *hīn*. This is, however, not the only case of such use of Tinné words by the Tagish. Nas-a-thane is doubtless Nī-sutlīn or Nī-sutlīn-hī-nī, the name of the river above the great lake. Krause names this river, on an Indian sketch attached to his map, Tis-lin-hin.

river, they jumped to the conclusion that it was the Hotalinqu of which he had told them.

This river still remains to be explored and mapped, and as it drains a country with a rather dry climate, the area of its basin is probably very considerable. It has been prospected to some extent by a few miners, but it is difficult, from the accounts which they are able to give, to ascertain much of a definite character respecting it. At the mouth of the river we met Mr. T. Boswell and two other miners who had spent most of the summer on it, and from Boswell's description, together with sketches subsequently obtained from Indians, the following notes are drawn up.

River not yet mapped.

The general tread of the Tes-lin-too appears to be south-eastward, and Boswell estimates its length, to the great lake, at one hundred miles. There are no rapids or falls in this distance, but the water for sixty or seventy miles from the mouth is moderately swift, the remaining distance to the lake being quite slack. The lake is represented as being at least one hundred miles in length, but accounts differ as to the existence of a large tributary river at its head, some affirming that there is merely a small unimportant stream. Be that as it may, the main continuation of the Tes-lin-too is found at the head of an arm ten or twelve miles long, on the east side of the lake. This river, known to the Tagish Indians as Ni-sutlĭn-hĭ-nĭ, must come from a north-easterly direction in the first instance, and it is represented as circling completely round the head of the Big Salmon River and rising between that river and the Upper Pelly. At a distance variously estimated at from eighty to one hundred and twenty miles from its mouth (and said by the Indians to be two days travel down stream), the river forks, the west fork being the larger and that of which the course has just been described. The east fork is swift and full of rapids and rises in a mountainous country, which no doubt represents a portion of the northern continnation of the Cassiar Range. The Indians travel several days up this fork and then cross mountains to tributaries of the Upper Liard and descend by these to the little trading post at the confluence of the Liard and Dease. Between the mouth of the main river and the forks above mentioned, the navigation is fairly good and no heavy rapids occur.

Tes-lin Lake.

The upper river

The great lake above mentioned, into which the Ni-sutlĭn-hĭ-nĭ discharges, is said by the Indians to be the largest known to them. It is named Tes-lin by the Tagish Indians, and is bordered to the westward, at a distance of several miles, by a high range of mountains, while a similar range, but of inferior height, runs along its east side and, further north, separates the Tes-lin-too from the Big Salmon. Near the head of the lake is an Indian trail by which, it is said, the head

Features near the lake.

Pass to Taku. of canoe navigation on the Taku River may be reached in two long days packing. Enquiry seems to show that the distance from point to point by this trail is about sixty miles, and that it crosses a range of mountains, but not at such a height as to pass entirely out of the timber. It is stated that a miner named Mike Powers, with eight or nine other men, crossed from the Taku to the lake in 1876 or 1877. These men built three boats on the lake, but do not appear to have done much prospecting and came out by the same route by which they had entered.

Gold. There are two Indian salmon-fishing stations on the Ni-sutlīn-hī-nī above Tes-lin Lake. Mr. Boswell and his partners found fine gold all along the Tes-lin-too and also on the Ni-sutlīn-hī-nī. They worked in different places along the river and appear to have done fairly well.

Tes-lin-too to Lake Labarge.

From the mouth of the Tes-lin-too or Newberry to the lower end of Lake Labarge the distance by the Lewes is twenty-seven miles and a-half. The river is very crooked and for the first six or seven miles very rapid, averaging probably six miles an hour. Large boulders occur in its bed in some places, but it is believed that a stern-wheel steamer of good power might ascend without difficulty. The current becomes slack three or four miles before reaching the lake. The river does not follow any well marked or important valley, but an irregular depression among lumpy inconsequent hills, none of which probably rise over 1000 feet above it. No rocks were found exposed on the river, but some of the hills are evidently composed in large part of pale, grey limestone. Scarped banks, about a hundred feet high, show boulder-clay overlain by white silts, which on the lower part of this reach of the river form about one-third of the height of the bank. The lakes above evidently prevent the occurrence of heavy floods on this part of the river, the sod coming down quite to the edge of the water in a manner not found on the lower part of the Lewes or on the Tes-lin-too where seen near the mouth.

Lake Labarge.

Nomenclature of the lake. This lake, through which the Lewes River flows, is undoubtedly that named for Mike Labarge on the older maps, though Schwatka names it Kluk-tas-si which is, no doubt, an attempt at its Tagish Indian name Tloo-tat-sai′. Krause calls it Tahiniwūd, which is evidently the name given to me as that of the Lewes River. (See p. 142 B).

The lake is a little over thirty-one miles in length. It lies nearly north-and-south, but is somewhat irregular in outline and does not present the parallel-sided form and constant width of most of the mountain lakes. About six miles of its lower end averages two miles and a-half in width. It then maintains a pretty constant width of a mile and a-half, for nine miles, after which it again increases in size and attains a width of five miles near Richtofen Island. (Named Richtofen rocks and shown as a peninsula on Schwatka's map). Its elevation above sea-level is approximately 2100 feet. It appears to maintain its level pretty constantly, the total rise and fall as indicated by the shores being about four feet only. It was about a foot above its low-water stage at the time we passed early in September. Size of the lake.

The lake is bordered nearly everywhere by hilly or mountainous country, but two important valleys occur which require special mention. The first of these evidently forms the continuation of the hollow occupied by the lake itself, and runs on from its north or lower end in a north-westward direction, while the river, where it leaves the lake, turns to the north-east and breaks through the ranges of hills on that side. The greater part of this valley, which I propose to name the *Ogilvie valley*, appears to drain from the lake in a north-westerly direction and probably to White River, as it is seen to be blocked by terrace-flats about 200 feet above the lake, at a distance of a few miles from it. The second valley begins in a tract of low land to the west of Richtofen Island and runs parallel to the first, being like it, one of the main orographic valleys of the region. A small river appears to enter the lake from this valley. The mountains on the south-west side form a well characterized range, but appear scarcely to exceed 2500 feet in height above the lake. They carried, however, some patches of old snow, the first seen by us since leaving the upper part of the Pelly River. Country about the lake.

The hills along the lower part of the lake on the east side are quite remarkable in their abrupt forms and have white limestone summits. They rise from 300 to 1000 feet above the lake and no higher mountains were seen behind them. Further up the lake, on the same side, similar limestone mountains attain a height of about 2000 feet at a short distance back, but are not so remarkable in form. On the west side of the lake, north of the Richtofen valley, the hills slope gradually back from the shore and in a few places reach a height of probably 2000 feet above it, at some miles inland. The outlines of these hills are monotonous and they are wooded nearly to the summits. South of the Richtofen valley the *Miner's Range* * approaches the lake at an oblique angle, but decreasing in altitude. The mountains forming this range are more varied in form than those just described. Mountains.

* I name this for the miners met by us along the river, good fellows all of them.

Survey of the shores.

Mr. Ogilvie's measured line was carried down from point to point along the west shore of the lake, a few points only having been fixed on the east shore by triangulation. In order to complete the outline of the lake I decided to make a track-survey of the east shore, connecting this by bearings with known points on Ogilvie's survey. We had not time to circumnavigate the lake and nothing was known to point out one side as better than the other for the purpose of geological examination. The lake is reputed to be a very stormy one, the prevailing winds being from the south in summer, and often so strong that miners have been detained in camp for many days. We lost almost the whole of one day, owing to wind, on our way up the lake. Though local evidence of a more humid climate was noted on the Lewes near the Seminow Hills, these are soon lost after passing that range, and along Lake Labarge, southern slopes of terraces and hills are often grassy and open. *Anemone patens* was noted as abundant in many places.

Climate.

Two series of rocks.

The rocks bordering the east side of Lake Labarge evidently represent two distinct series, of which the older is for the most part composed of grey limestone; which, in some places, nearly approaches marble but in others becomes rather flaggy and argillaceous. Resting unconformably on this, is a series composed of conglomerates, which pass into hard grey and greenish grauwacke-sandstones, and hard, dark, calcareous shales which occasionally become nearly black, impure, flaggy limestone. The two series are folded together, the strike of both being north-north-west and meeting the shore of the lake very obliquely. The direction of dip is generally westward at high angles or vertical. The conglomerates are chiefly composed of greenish, grey and purplish altered volcanic rocks, together with limestone of various kinds, and the same constituents in a more comminuted form enter into the composition of the grauwackes. At a point opposite Richtofen Island, black, argillaceous and calcareous beds are charged with numerous angular fragments of the older limestones, the occurrence of which and of the pebbles of altered volcanic rocks elsewhere associated with the limestones, constitute the evidence of unconformity, as the two series are too closely folded together to admit the observation of an angular unconformity. The good exposures found along this shore of the lake are important as indicating the intimate manner in which the rocks of differing age are associated in this region. They show that their separation on the map can be accomplished only by means of a detailed survey. No characteristic fossils were found in the older limestone series which may, however, be regarded from analogy as probably of Carboniferous age. The newer series is evidently Cretaceous and very probably of the horizon of Series C., the Lower Shales and Sandstones of the Queen Charlotte Islands. A few fossils were obtained at the point

already referred to, opposite Richtofen Island, on which Mr. J. F. Whiteaves supplies the following note.—

"The fossils collected at this locality appear to be somewhat as follows, though they have only been subjected, so far, to a preliminary and by no means exhaustive examination. 1. A single specimen of a small sponge, and, (2.) several badly preserved corals, one with compound and very slender corallites. 3. Several small lamellibranchs apparently referable to three genera, two of which are represented by mere fragments, while the other may be a form of *Pleuromya lævigata*. 4. A mould of part of a spiral gasteropod, which may be referable to *Nerinæa* or to the genus *Pseudomelania* of Pictet and Campiche. 5. A piece of a phragmocone of a small belemnite. **Cretaceous fossils.**

"These fossils, though somewhat obscure, appear to be of Cretaceous age and possibly of about the horizon of Series C., of the Queen Charlotte Islands."

Of the rocks on the opposite or west side of the lake nothing certain can be said. Limestone is, however, not a prominent feature in the hills near the lake, though apparent in some of those seen behind the first range. It is not improbable that the Mesozoic rocks are here more extensively developed.

Terraces were noted on the lower part of the lake at about 200 feet above it and at various lower levels, and near the head of the lake they were seen at an elevation estimated as being at least 400 feet above it. **Terraces.** The rocks along the lake-shore frequently show glaciated surfaces, the bearing being in general parallel to that of the lake and the sense of the movement of ice from south to north. The limestone **Glaciation.** hills are channelled, planed and fluted along their sides and over their summits in such a way as to indicate the former existence of very heavy ice pressure. Two miles from the lower end of the lake, at the water-level, the glaciation points directly down the valley through which the river now runs, or N. 24° E., while two miles further on, the summit of a limestone hill 300 feet high is crossed by heavy glaciation running N. 8° W. The latter may be accepted as that of the main direction of motion, the divergence met with being not greater than that frequently found in tracing the course of the ice of the former Strait-of-Georgia glacier on the coast, where it has passed over rugged country,* and it would appear that in this case the main mass of ice moved into the wide Ogilvie valley, while part of the lower portion of the mass was pressed through the smaller valley by which the lake itself now discharges. Where the limestone hills have recently been stripped of their covering of soil, the sloping glaciated surfaces are still so smooth that it is difficult to walk over them.

* See Annual Report Geol. Sur. Can., 1886, p. 100 B.

Origin of the lake.

No definite indication of the mode of origin of the lake was obtained. The observation just cited shows that the valley through which it now discharges existed in glacial times, but it may probably have been of less importance and it is not impossible that before the glacial period the river flowed out by the Ogilvie valley which may since have become blocked by morainic or other drift deposits.

Lake Labarge to Tahk-heena River.

The valley.

Beyond the head of Lake Labarge, the valley of the Lewes continues equally wide, and runs in a general southward direction like that of the lake. At the head of the lake, the valley is occupied by swampy flats nearly at the water-level and by low terrace-flats, which, where cut in the river banks, are seen to be composed of stratified fine sands, which are often iron-stained and a few miles up the river are found to rest upon the white silts, showing that they are valley deposits of post-glacial date. The limestone range which has bordered the east side of Lake Labarge, runs on in a southward direction, forming the east side of the wide valley. Eleven miles and a-half from the head of the lake the Tahk-heena River flows in from the west, making a right angle with the main river and at thirteen miles further (still measuring along the river), the foot of White Horse Rapid is reached. The current of the Lewes is rather slack for eleven miles from the lake, and the bed and banks are clayey or sandy. Above this point, the river becomes swift, averaging about four miles an hour, and gravel banks and bars re-appear. For about two miles below the White Horse Rapid, the current is very swift, and though the latter may be designated as the head of possible steamer navigation, it would scarcely pay to endeavour to force a steamer up to th every foot of the rapid.* No rock exposures what ever were seen along this part of the Lewes, the scarped banks, which are often a hundred feet in height, consisting almost entirely of white silts with a widely undulated bedding.

The river.

Tahk-heena River.

Size of the river.

The Tahk-heena† River is a considerable stream and is wide and slack at its confluence with the Lewes. At about 200 yards from the Lewes, where it has attained its normal size, it was ascertained to be 237 feet wide, with a depth of ten feet for about one-third of this width,

* Several small stern-wheel steamers have, for some years, ascended each summer the Lower Yukon, in Alaska, but so far as I know, none of these have yet gone further up than the mouth of the Stewart; it would, however, be quite practicable to ascend to the point here indicated.

† Named the Yukon at its outflow from "west Kussooä Lake" at its head, on Krause's map. The orthography of the published maps is here retained. The name would probably be more correctly rendered Ta-hī-nī.

and a current estimated at two miles an hour. The discharge may be roughly estimated at 3600 cubic feet per second, and appeared to be about half that of the Lewes above the junction or one-third of that below the confluence. The hills which border the south side of this river at its mouth, rise to high rugged mountains at about fifteen miles to the west, and these have the appearance of being largely composed of granite. The water of this river is very turbid as compared with that of the Lewes, and the temperature of both rivers was found to be 52° F. on the 6th of September.

Upper part of the river.

The principal sources of the Tahk-heena are shown by Dr. A. Krause's exploration to be at a distance of forty to fifty miles from the head of the west branch of Lynn Canal, and the river was formerly much employed by the Chilkat Indians, whose chief place is on that arm, as a means of reaching the interior. It is not used by the miners, and now only to a small extent by the Indians themselves, on account of the long and difficult carriage from the sea to its head, but the lake at the head of the river once reached, the voyage down stream is reported to be easier than that by the main river, the rapids being less serious. A sketch of the course of the Tahk-heena River, probably based on Indian accounts, is given on map No. 20 which accompanies the U. S. Coast Survey Report for 1867. This sketch has, however, not been employed on the map of of 1884, it being probably supposed at that time that the Indian information on which it had been drawn referred to the upper part of the Lewes.

The Cañon.

White Horse Rapid.

The White Horse Rapid and Miles Cañon form together the most formidable obstacle to the use of the Lewes as a route into the interior, constituting an interruption to navigation of two and three-quarter miles in total length. White Horse Rapid is three-eights of a mile long.* The worst rapid is at the lower end of the White Horse, where the river scarcely exceeds a hundred feet in width, with low basaltic banks, and the force of the water is very great. In the upper part of the White Horse, the water flows between low basalt cliffs scarcely exceeding twenty feet in height, but sufficient to render tracking precarious and difficult, while the occurrence of numerous rocks in mid-channel makes the rapid dangerous to run. The portage is on the west bank and it is usual to carry both boats and cargo over it.

Between the White Horse and the foot of the cañon the river is very swift, and at one place, a mile above the former and three-quarters of a mile below the latter, the set of the stream is so strong round a rocky

* The distances here given are those measured by Mr. Ogilvie.

point as to render it advisable to make an additional short portage of 130 feet. A third portage of five-eighths of a mile is necessary at Miles Cañon. This portage is on the east bank, and at the lower end, a very steep ascent has first to be overcome. Here a sort of extemporized windlass has been rigged up by the miners for the purpose of hauling up their boats. The cañon is cut through a horizontal, or nearly horizontal, flow of basalt and is not more than about a hundred feet in width, with vertical cliffs averaging about fifty feet, and never exceeding one hundred feet, at the sides. It opens out into a species of basin in the middle, but the river is elsewhere inaccessible from the banks. Terraced hills rise above the basalt walls on each side of the valley, but are particularly abrupt on the west bank. The river flows through the cañon with great velocity, but is unimpeded in its course, and it is therefore not very risky to run with a good boat. The White Horse Rapid is, however, much more dangerous, and though some of the miners have run through it—generally accidently—it should not be attempted.

The cañon.

Basaltic rocks.

The basaltic rocks of the rapid and cañon are not seen for any distance above or below these points, and appear to represent a local effusion of no great area, which is probably confined to the bottom of the valley. A second wide valley runs behind *Cañon Hill*, to the east, and it is possible that this may represent a pre-glacial channel of the river. The basalt is itself evidently older than the glacial deposits. It is grey in colour and often vesicular, the cavities being in some places filled by a radiating zeolitic mineral.

Miles Cañon to Lake Marsh.

Lewes River and valley.

The great structural valley which is occupied by Lake Labarge and by the river above it up to this point, runs on above the cañon as a wide, important depression, bearing nearly due south, and appears to be uninterrupted till it joins the lower end of Bennett Lake, thirty-two miles distant. The course of the river, however, diverges to the south-east, in which direction also a wide valley runs, and in twenty-three miles (following the stream) the lower end of Lake Marsh is reached. This valley, though extensive between its limiting slopes, is not regularly bounded by parallel ranges, like that first mentioned. The current of the river to within five or six miles of the lake is moderate, not exceeding three miles an hour, and the immediate river-trough is narrow, being rather closely bordered by terraces of a hundred feet or more in height. Above this point, to the lake, the current is quite slack; the terraces gradually retreat toward the bases of the hills, and wide, swampy flats occur. The water above the cañon is quite clear and

blue, showing that its turbidity further down is entirely due to the washing away and falling in of the high banks of silt. The turbidity of the Tahk-heena is probably also due to the same cause.

Anemone patens and *Elæagnus argentea* are common on dry banks, and slopes covered with bunch-grass and *Artemisia frigida* still occur, evidencing a dry climate. The black pine (*Pinus Murrayana*) is now very abundant, much more so than on the lower river, and it was here observed that this tree began to assume a more branching and less rigid form than it has to the north. Large numbers of salmon were found dead or dying along the banks for a few miles above the cañon, and the grass along the shores was trodden down by bears attracted here by this circumstance. No salmon were found so far up as Lake Marsh, and the Indians state that this is their limit. It would appear that after their long journey from the sea, those which get so far, exhaust their last remaining strength in ascending the cañon. **Vegetation.** **Salmon.**

There are some very fine exposures of stratified white silts, often interbedded with sands, along this part of the river, but no boulder-clay was seen; neither are there any exposures of rock in place. Basalt is seldom found as a constituent of the gravels above the cañon, and then only in small pebbles. Rounded pieces of greenish, jade-like rocks and impure jades, which were abundant below the Tes-lin-too, here again become common. **White silts.** **Jade.**

Lake Marsh.

Lake Marsh, so named by Schwatka, in honour of Prof. O. C. Marsh, is known to the miners as "Mud Lake." It is twenty miles in length, with an average width of about two miles, pretty uniformly maintained. The valley of which this lake occupies the centre, is notably wide, and the country in the immediate vicinity of the lake is quite low, consisting of terrace-flats, or low rounded or wooded hills and ridges. Conspicuous mountain summits, however, occur at a distance of some miles inland on both sides of the lake. A moderately well defined range, of which Michie Mountain* 5540 feet in height is the most elevated point, bounds the view on the east side of the lake, from which it diverges in a south-easterly direction. To the west is an irregular and broken mass of mountains in which several notable gaps occur and which occupy the country between Lake Marsh and the Watson valley, previously referred to. The highest points of these, *Mounts Lorne* and *Lansdowne*, were ascertained to have approximate elevations of 6400 and 6140 feet respectively. The diversified forms of the mountains in view from this lake render it particularly picturesque, **Situation of Lake Marsh.** **Mountains.**

* So named by Schwatka.

and at the time of our visit, on the 10th and 11th of September, the autumn tints of the aspens and other deciduous trees and shrubs, mingled with the sombre greens of the spruces and pines, added to its beauty.

The lake and its tributaries.

The shores of the lake are generally rather shoal, and in some places the beach-gravel was found to rest on mud or clay, but these peculiarities are not so striking in themselves as to warrant the application of the name "Mud Lake." The mouth of the M'Clintock River, which enters the lower end of the lake from an important valley, was not examined closely. It appeared, however, to be a small stream, and the greater part of the country to the east of the lake probably drains to the Tes-lin-too. A second stream joins the lake at the south-east angle at its head.

Track-survey.

As in the case of Lake Labarge, Mr. Ogilvie's measured line was here carried along the west shore and in order to complete the outline of the lake, I travelled up the opposite side, making a track-survey of it, which has been embodied on the map.

Rocks.

The rocks seen at the lower end of Lake Marsh, and on the island, may be taken as representing the composition of the range which borders the Lewes on the north-east for some distance below. They consist of greenish and purplish altered volcanic materials, probably all diabase in composition, and are bedded, the strike being approximately parallel to the run of the range just mentioned.* Further up the lake on the same side, similar rocks were noted in several places, together with some which might be taken to represent the grauwacke-sandstones of the newer series described on Lake Labarge. The higher mountains off to the eastward appear to be, at least in part, composed of limestone. At the head of the lake are considerable exposures of black and dark-grey, hard, slaty argillites, finely cleaved and traversed by numerous small quartz veins. The strike of the cleavage is S. 30° E., with a high easterly dip.

Glaciation.

The rock surfaces along the lake are heavily glaciated, the direction being, in general, parallel to that of the main valley. The evidence is such as to show, however, that at least the subjacent part of the ice of the former great glacier, bifurcated at the north end of the lake, one branch taking the valley of the Lewes, the other that of the M'Clintock River. In the same way, at the south end of the lake, a great part of the ice has been delivered through the wide valley which comes from the south-east between *Jubilee Mountain*† and *Mount White*.‡

* See Appendix V. (Lake Marsh, No. 86) for note on one of these rocks.

† 1887 being the year of Her Majesty's jubilee.

‡ So named in honor of the late Hon. Thos. White, to whose initiative the despatch of the expedition to which this report refers was largely due.

Tagish, Bennett and Lindeman Lakes.

The upper end of Lake Marsh is connected with Tagish Lake by a wide tranquil reach of river five miles in length. The current is here very slack, and the depth, according to Ogilvie, from six to twelve feet. The river is bordered by low terraces, which are particularly wide on the west side, and are covered with open woods, chiefly consisting of white spruce and cottonwood. To the east, the long irregular ridges and slopes which culminate in Jubilee Mountain begin to rise a short distance back from the river. A mile above Lake Marsh, on the east bank of the river, are two roughly built houses belonging to the Tagish Indians. These are the only permanent houses seen along the whole course of the Lewes, and here the Tagish people who roam over this part of the country, reside during the winter months. Connecting river. Indian names.

From the description just given, it will be seen that the navigation, by steamers, from the head of the cañon through Lake Marsh and to Tagish Lake would offer no difficulties, while the tranquil character of the connecting river between the two lakes last mentioned, is such as to practically render Lake Marsh the lower portion of an extensive system of still-water navigation which includes not only Tagish Lake but also Lake Nares, Lake Bennett and possibly other connected waters and which will prove of the greatest utility at no distant date in facilitating the opening up and development of the mineral resources of the tract of country in their vicinity. Navigable waters.

The through distance, from the lower end of Lake Marsh to the head of Lake Bennett, measured along the central line of the various lakes and connecting waters, is about seventy miles, made up as follows.—

Marsh Lake	20	miles.
River	5	"
Tagish Lake	16·6	"
Lake Nares	2·7	"
Bennett Lake	25·8	"
Total	70·1	

The still-water navigation, however, includes also the West Arm of Bennett Lake, about twelve miles; Windy Arm of Tagish Lake, eleven miles; Tako Arm of same lake, (of which some notes are given below) at least twenty miles; making a grand total of at least one hundred and thirteen miles.

Taken as a whole, these lakes constitute a singularly picturesque region, abounding in striking points of view and in landscapes pleasing in their variety, or grand and impressive in their combination of rugged mountain forms. Scenery.

Height above sea-level.

The elevation of this remarkable system of lakes above the level of the sea, as approximately ascertained by the mean of about eighteen barometric observations extending over several days, (all taken in triplicate on as many different aneroids,) is 2150 feet. The mean of the barometer readings was compared with that of those taken during the same days at Haines' mission, on Lynn Canal, and the resulting height as above given, is probably a near approach to the truth.

Position relatively to Coast Ranges.

The inner or north-eastern edge of the Coast Ranges is not here very well defined, but Tagish and Bennett Lakes, with their several arms, may be described as lying upon this border and as in part penetrating the outskirts of the range. The lower part of Tagish Lake occupies the continuation of the same wide valley in which Lake Marsh lies, and the valley of the Tako Arm may also be included as a part of the same depression. To the west of this, the upper part of Tagish Lake and Bennett Lake must be considered as lying among the mountains of the Coast Ranges, and the height as well as the abrupt and rugged character of the mountains increase in that direction, their slopes and summits holding large areas of permanent snow, even late in the summer.

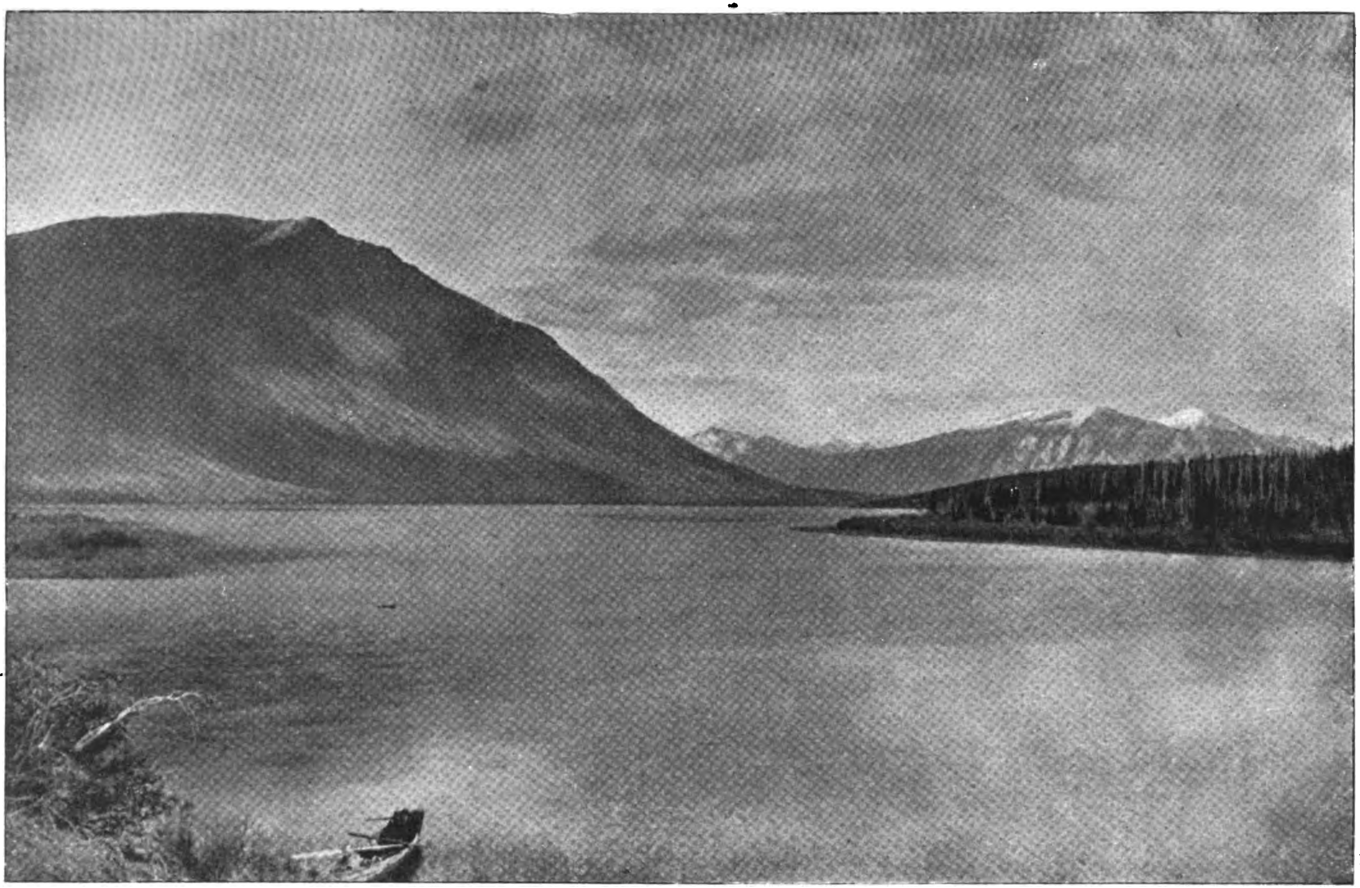
Connection of the lakes.

The lower part of Tagish Lake is very generally bordered by terrace-flats or by low land of the nature of terraces, and the valley runs through to the lower end of Bennett Lake, with a nearly uniform width, as measured between the bases of the mountains, though the lake is somewhat constricted between Tako and Windy arms by the extension of the low land from the north side. A similiar projection of low alluvial land separates Lake Nares from the west end of Tagish Lake, a river-like current being distinctly observable in the narrows. The same occurs at the narrows known as the Caribou Crossing which separates Nares from Bennett Lake, but here with the addition of a number of irregular sand-hills, with which the low land in question is covered, and which also extend round a considerable part of the north end of Bennett Lake.

Arms of the lakes.

The Windy Arm of Tagish Lake, together with the upper part of Bennett Lake and its West Arm are comparatively narrow mountain-walled inlets, with all the characters of true fiords. The Windy Arm terminates in low, hilly land, from which a couple of small brooks come, but no important stream; and it would appear that the drainage which might be expected to enter here is cut off by a transverse valley which holds a lake and flows out toward the Tako Arm.

The West Arm of Bennett Lake was not explored to the head, but terminates in a mass of wild, rugged and bare mountains, of which the outline sketch given on p. 167 B may give some idea. The upper part of the main lake lies, as a narrow water-way, between beetling granite ranges which rise almost perpendicularly to heights of 3000 and 4000



G. M. DAWSON, PHOTO., SEPT. 14, 1887.

G. E. DESBARATS & SON, ENGRAVERS & PRINTERS, MONTREAL.

LAKE NARES, LOOKING EASTWARD FROM CARIBOU CROSSING.

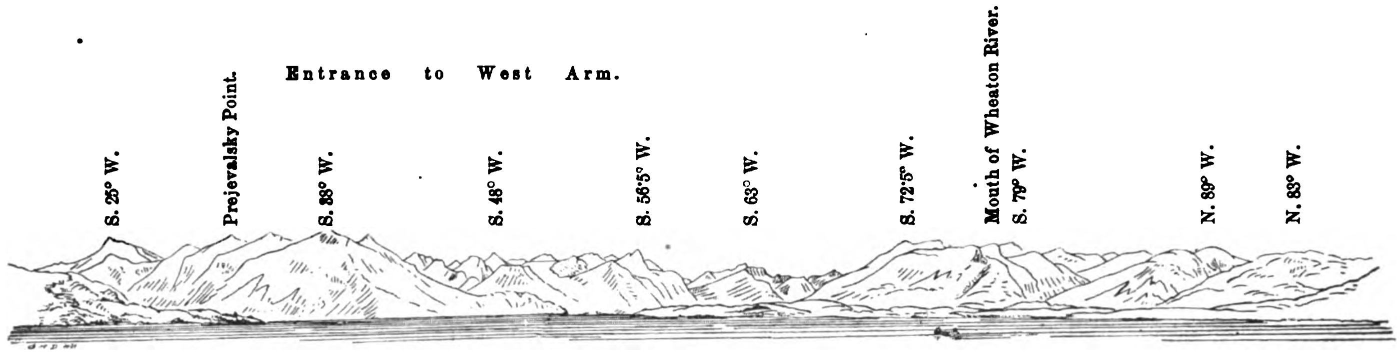


FIG. 7. LOOKING TOWARD COAST RANGES, UP WEST ARM OF BENNETT LAKE, FROM EAST SIDE OF LAKE.

(The figures placed above the various summits are true bearings.)

feet above it. Many of the summits beyond the heads of these fiords and in the vicinity, attain heights of 6000 to 7000 feet above the sea, and the region is in every sense an alpine one, though no dominating peaks of great altitude occur.

Climate and vegetation.

In consequence of the position of this country, in the lee of the higher crests of the Coast Ranges, and notwithstanding its considerable altitude, the climate appears to be equally dry with that met with about the site of old Fort Selkirk, and no very striking difference is met with in the character of the vegetation. The southward-facing slopes of some of the mountains, to a height of a thousand feet or more above the lake, are grassy and open, a circumstance particularly observable on the north side of the west part of Tagish Lake and on Lake Nares. The *Amelanchier* was seen on the lower part of Tagish Lake, this being the most northern station observed, and *Anemone patens* continues abundant, locally. Somewhat more alpine conditions are, however, indicated by the occurrence of *Picea subalpina*, which was noted as abundant at the water-level on Windy Arm, and on the upper part of Bennett Lake forms entire groves, growing to a considerable diameter, but tapering rapidly and very rough and knotty. Several places were, however, noticed where miners had built boats on Bennett Lake, and it was here that Mr. Ogilvie constructed a large scow for the transport of his provisions and bulky freight down the river.

Tako Arm.

The Tako Arm, which has already been alluded to, really constitutes the main continuation and upper part of Tagish Lake. It is narrowed at its entrance to a width little exceeding a mile, by a promontory from its west side, but further on, maintains pretty uniformly, for ten miles or more, a width of a mile and a-half to two miles. It is bordered on the west by a uniform, bare and wall-like range of limestone mountains, between which and the edge of the lake, however, a certain width of lower slopes intervenes. The east side is similarly bordered by mountains which also appear to be in the main composed of limestone, but the forms of these were not so well seen, as they were continuously covered by clouds and mists while we were near them. This arm was not explored and with its connected waters yet remains to be properly delineated on the map. It runs in a south-eastward direction for a distance estimated at ten miles, beyond which it turns more nearly south, and its length and other features connected with it can only be given on the authority of Indian reports and sketches. A long way up this arm, possibly twenty miles or more, a considerable river enters from the east. This is the main continuation of the Lewes and is reported to be a tranquil stream of no great length, resembling that between Marsh and Tagish lakes. It flows out of the west side of an-

other very long lake which lies nearly parallel to Tahko Arm. This lake, near its south end, receives several feeders, one of which, entering at its extremity, I suppose to be the Hotalinqu River of the Telegraph Survey, already mentioned, though the Tagish Indians informed me they named it Yil-hĭ-nĭ. It is probably the south end of this lake which was reached by Byrnes in 1867, and its connection with the Tako Arm and the remarkable system of lakes just described, would explain the statement made to Byrnes by the Indians, viz. that it was three days good paddling in a canoe to the lower end of the lake. The length of the portage from the head of this lake to the Indian houses on the Taku was variously stated by Indians at from two to four days. The trail is said to be good, and to run through low country except at one place where it follows along the mountain to avoid swampy land. The name of this lake was given by one Tagish Indian as *A-tlin*, by another as Tā-koo-shok and again Sik-ĭ-nĭ-kwan, the last being said to be the Taku Indian name. The first-mentioned name is adopted on the map.

Connection with Taku River.

It is certain that the greater part of the water constituting the Lewes River enters by the Tako Arm. This is rendered apparent in comparing the stream which flows out of Tagish Lake with that entering it by the narrows from Lake Nares, where the discharge is probably not much over one-fourth of the volume of that of Tagish Lake. The brooks entering Tagish Lake (exclusive of Tako arm) are quite insignificant.

Main source of Lewes River.

The Indian name of the lake here named Tagish Lake, is Ta-gish-ai (Tagĭschā of Krause). It is commonly known by the miners as Tako Lake, and Schwatka adopts this name on his map. It appears, however, admissible to revert to the proper Indian pronounciation of the name, as is here done. I am obliged, by the facts of the case, to include Bove Lake, of Schwatka, as part of Tagish Lake, but in order to preserve the name, propose to attach it to the large island in the mouth of Windy Arm. Lake Nares is known to the miners as "Moose Lake," Lake Bennett as "Boat Lake." In these cases, though not without some doubt as to the propriety of so doing, I retain Schwatka's later names. The Tagish Indian name of Lake Bennett is Koo-soo-wā'. It is the East Kussooā Lake, of Krause. Its west arm is called Noo-koo-tahk. The name of the island on Bennett Lake is Ketle-di-kā'-te. I did not ascertain the Indian name of Lake Nares. The islands on Tagish Lake, of which Bove Island is one, are named In-te'-i.

Names of the lakes.

It will be observed, on comparing Lieut. Schwatka's map with that now published, that he names the west arm of Bennett Lake (though nearly two miles wide at the mouth) "Wheaton River." To the river which enters near this arm from a valley parallel to the Watson

Observations by Schwatka.

valley, I propose to apply this name. In the same way, Windy Arm is put down as "Bove Bay and probably river," and the great Tako Arm is shown as "Tako River," and described as a stream of inconsiderable dimensions. I can offer no reasonable explanation of these errors.

Geology of the Lakes.

General character of the rocks.

The eastern edge of the granitic rocks of the Coast Ranges, is found to cross Bennett Lake obliquely, and probably runs northward along the Wheaton valley. The rocks exposed on the lakes to the east of this line, may be described as belonging, in so far as ascertained, to a single great Palæozoic series, of which the sub-division cannot yet be attempted, but in which the only fossils found by us are of Carboniferous age. It is the same to which the older rocks on the Lewes belong, and closely resembles, both lithologically and in its fossils, the typical area of the Câche Creek series on the Thompson and Fraser. The series, as a whole, here consists of massive limestones, with a great thickness of green and green-grey diabase and felsite rocks, representing altered volcanic materials, and dark- or light-colored cherty quartzites and argillaceous or calcareous schists. The order of superposition is uncertain, but the limestones appeared probably to constitute an upper member of the series, and to be closely associated with the more important masses of contemporaneous volcanic material, while the cherty quartzites and schistose or slaty beds may follow respectively in descending order beneath the limestone. Volcanic materials are, however, fond in greater or less quantity in all parts of the series.

Schists.

Black argillaceous schists and grey, silvery calc-schists were found on the east side of Tagish Lake, between the lower end and the entrance of Tako Arm, and again at the head of Windy Arm, in considerable force. At the latter place, the argillite is finely cleaved, forming a true slate. It contains quartzite pebbles, which have been remarkably sheared by pressure acting at right angles to the cleavage-planes and doubtless the same which has produced these. The great mass of limestone occurs in the ranges bordering Tako Arm on both sides and in the mountains between this arm and Windy Arm. It is generally in the state of marble, and usually rather fine grained, many specimens being very handsomely and curiously marked with grey and black lines or spots. Some beds contain a good deal of silica, and weather rough, occasional layers are more than half composed of cherty matter. Numerous crinoidal remains are often visible, and a microscopical examination of thin sections, prepared by Mr. T. C.

Limestone.

Weston, proves some parts of the stone to be largely composed of the remains of *Fusulina*.* Fusulina.

To the west of this great limestone belt and between it and the edge of the granites, most of the rocks consist of altered volcanic materials, as previously described. Some distinct amygdaloids were observed among these, but no minute lithological examination of them has been made.† Altered volcanic rocks.

The eastern edge of the granites is reached at about ten miles up Bennett Lake, on the east side. Granites continue thence, on the same side, for about five miles and a-half; when they are replaced for five miles by an included belt of stratified rocks, chiefly quartzites, but including also some hornblendic schists. This belt crosses the lake very obliquely in a nearly north-and-south bearing, and appears to represent a detached portion, more highly altered, of the Palæozoic rocks before described. Edge of granites.

The quartzites are here much shattered and pyritized, weathering to rusty surfaces and causing the red appearance of some of the mountains. The same rocks were seen from a distance in the mountains to the west of the lake, but the greater part of the mountains on the west side is evidently granite.

The granites seen along the shores of Bennett Lake are generally rather coarse-grained and hornblendic, though an abundance of black mica is also developed in some places. The felspar is not uncommonly of two kinds, a pink (probably orthoclase) which is often in large porphyritic crystals, and a white triclinic variety. The general tint of the rock is grey, and it closely resembles those described from the vicinity of Vancouver Island in the Annual Report for 1886. No gneissic structure was observed, and the micaceous and hornblendic schists locally developed at the junction with the stratified series, are no doubt the result of the extreme alteration of volcanic portions of that series. Character of granites.

Glaciation was observed in many places in this system of lakes. It is unnecessary to specify these, but it may be stated that conclusive evidence is afforded that glacier-ice moved northward, down Tako Arm, Windy Arm and Bennett Lake, as well as eastward, nearly at right angles, in the east-and-west part of the lake between Windy and Tako arms. This eastward motion was, however, probably subordinate and local, for no great number of granite boulders is found about the lakes till the lower end of Bennett Lake is reached, a circumstance which Glaciation.

* The *Fusulinæ* found here are often remarkably large. The largest actually observed in the few slices prepared for microscopical examination has a transverse diameter of 0·25 inch. Fragments occurring in the same slides, however, indicate the existence of much larger individuals. No critical examination of these fossils has yet been made, but they appear referable to *Fusulina robusta* (Meek), found in California. Palæontology of California. vol. i., p. 3.

† In Appendix V. (Tagish Lake, No. 93), some notes on a felsite from Windy Arm are given.

show that the main mass of ice passing down the Bennett Lake valley continued on to the north by the Watson valley. Well marked and extensive terrace deposits occur on the mountains on the north side of Tagish Lake, at an elevation estimated at 1000 feet above it, or about 3100 feet above the sea-level.

Valleys of the lakes.

A glance at the map will show that the lakes of this system occupy a portion only of a still more extensive system of wide valleys, which are probably of great antiquity, and the pre-glacial direction of drainage in some of which can only be conjectured. All these valleys are now, to a great extent, filled with detrital deposits, probably due for the most part to the glacial period. No appreciable deepening of drainage levels is going on, and the action at present in progress is constantly tending toward the filling up of the lake-basins. It may be presumed, here as elsewhere, that the lakes of this region now occupy the place of the last tongues of the great glacier, which in the end disappeared so rapidly that their beds had not time to become filled with detritus.

Lake Lindeman.

Lake Lindeman, occupies the continuation of the same valley in which Lake Bennett lies, but is separated from that lake by a small rapid stream, three-quarters of a mile in length. This stream falls about twenty feet between the two lakes and is rough and rocky. The portage is on the east side, and after carrying the greater part of our stuff overland, no difficulty was experienced in bringing the boat up the rapids. Lake Lindeman (Tĭ-tshoo-tah-min' of the Tagish Indians Schütlüchroā Lake of Krause) is five miles in total length, with an average width of about half a mile. It is the extreme head of navigation in this direction. The lower end is shallow, and the occurrence there of many large boulders, may show that it is moraine-dammed. Its shores are rough and rocky along both sides, high rough mountains rising on its north bank, while lower country, consisting of rocky hills, extends to the south-eastward, as far as the White Pass. A stream joins the head of the lake from the west, in which direction the main valley runs, but bifurcates at a distance of about three miles, the branches running off among high granite mountains. A second stream of some size, which shows evidence of being a formidable torrent at certain seasons, flows into the lake about a mile from its head, on the south side. It is the valley of this stream which is followed by the trail by which the Coast Mountains are crossed. The scenery about this lake is wild and fine, though solitary and alpine in the extreme. The rocks everywhere about the lake are granites of the kind just described.

As a number of miners had preceded us, on their way to the coast, we found several boats drawn up on the shore at the mouth of the stream above mentioned. We were also so fortunate as to find a small party of Tagish Indians camped there, but as most of the men had

G. M. DAWSON, PHOTO., SEPT 19, 1887. G. E. DESBARATS & SON, ENGRAVERS & PRINTERS, MONTREAL.

LAKE LINDEMAN, LOOKING UP FROM OUTLET.

already gone over the portage with some of the miners, we were obliged to wait two days for their return, before we could obtain the requisite assistance to carry over our stuff. Meanwhile we put our boat in a place of security, and occupied ourselves in eliminating everything which was no longer of value from our "outfit."

General Notes on Lewes River.

The total length of the route by the Lewes River from "the Landing" on Lake Lindeman to the site of Fort Selkirk is 357 miles. From the outlet of Lake Labarge, to the same point, is a distance of 200 miles, in which the total descent is 595 feet, or at the rate of 2·97 feet to the mile. Length of route

The information obtained respecting the dates of opening and closing of the river in spring and autumn is very fragmentary. It would appear, however, that the rivers generally throughout the region open early in May, while they may be expected to freeze over, in slack-water reaches, any time after the middle of October, on the occurrence of a few consecutive days of hard frost. Loose ice sometimes begins to run in the rivers as early as September 20th, but this generally precedes the actual closing of the rivers by a couple of weeks. In some seasons the rivers do not freeze over till well on in November. The ice, however, remains much longer unbroken upon the lakes, the lakes on the course of the Lewes thus generally preventing the descent of that river by boats till June. In 1887, some of the lakes were not open for navigation till June 10th, but as already mentioned the season was an unusually late one. The Tes-lin-too could be crossed in places on ice-jams as late as May 22nd in the same year, but was open throughout within a day or two after that date. Opening and closing of rivers

Miners entering the Yukon district by the Chilkoot Pass and Lewes River, frequently leave the head of Lynn Canal in April, and after crossing the pass,—for which fine weather is essential,—continue on down the lakes on the ice, and then, if necessary, wait at some convenient point for the opening of navigation, and build their boats. Travel on the river.

In ascending the river, much depends on the build of the boat employed and skill of the men in poling, as well as on the occurrence, or otherwise, of head-winds on the lakes. The whole distance from Forty-mile Creek to Lake Lindeman has been made once or twice in so short a time as thirty days, and I believe that even this record has been surpassed by a couple of days on one occasion, but under very exceptional circumstances.

Our actual travelling time, from the mouth of the Lewes to the lower end of Lake Labarge, deducting all stoppages, was 121 hours, 15 Travelling time

minutes. From the head of Lake Labarge to the lower end of Lake Marsh, deducting stoppages as before, and not including the time occupied on the portages (at White Horse Rapid and Miles Cañon) 25 hours 55 minutes. Much, however, depends on the stage of water in the river, as when it is unusually high, the current is not only stronger but many of the bars and beaches are covered, and the poling and tracking is much worse. The time occupied in traversing the lakes is not included in the above statement.

Timber.

Timber suitable for building boats can scarcely be found in the vicinity of Lake Lindeman, but no difficulty is met with in obtaining trees of fair size on Bennett and Tagish lakes. Below these lakes, the country is generally wooded, and there is an abundance of spruce of fair quality, growing tall and straight in sheltered localities, but seldom attaining a diameter of two feet.

CHILKOOT OR TAIYA PASS.*

Cross Chilkoot Pass.

On the 19th of September we set out with four Indian packers, crossed the summit, and reached a point in the valley of the west slope near what is known as Sheep Camp, the same evening. On the evening of the 20th we arrived at the head of tide-water on Taiya Inlet, and were hospitably received by Mr. J. Healey, who has established himself at that point for purposes of trade with the Indians and miners. We had at this time just completed our fourth month of arduous and incessent travel from Wrangell, at the mouth of the Stikine River, by the rivers, lakes and portages of the interior described in the foregoing pages, the total distance traversed being about 1322 miles. No serious accidents had befallen us by the way, and though, like the miners, we came back to the coast with a deplorably ragged and uncouth aspect, we had with us, intact, our collections, instruments, survey-records and notes. It was not the least pleasing moment of the entire journey when, from a distance of some miles, we first caught sight of the sea shining like a plate of beaten bronze under the rays of the evening sun.

The Pass.

The length of the mountain portage from Lake Lindeman to Healey's house, is twenty-three miles and a-half, the summit of the pass being at a distance of eight miles and a-half from Lake Lindeman, with an elevation of 3502 feet.

The valley on the north or inland side of the summit contains several little lakes which are evidently true rock-basins, with lumpy bottoms and irregular contours. The trail is rough and crooked, and entirely

* Known as Chilkoot Pass by the miners, named Perrier Pass by Schwatka. (1883). Dejäh Pass of Krause (1882) of which Taiya is merely an alternative rendering adopted for the sake of conformity with published charts.

without attempt at improvement of any kind. It follows the stream in one place, for about a mile, through a narrow rocky defile, which has evidently been cut out since the glacial period. Where it crosses wide areas of shattered rocks, it requires the closest attention to follow it, and this can only be done, in the absence of guides, by noting the slightly soiled appearance of the grey stones from one to another of which the Indians step. Some of the valleys to the north of the summit, and near it, are deeply filled with perennial snow, over which the trail runs by preference, to avoid the rocky slopes. The small lakes highest in the pass were, at the time we crossed, about two-thirds covered with new ice, which showed little sign of melting, even under the bright sun which prevailed. Hard frosts were evidently occurring here in the mountains every night at this season. Character of the route.

From seven to eight miles of the highest part of the pass may be said to be entirely destitute of timber, even of a stunted growth such as might be used for firewood. The nature of the ground is, however, so rocky that it does not afford a proper criterion of the normal height of the timber-line. Timber-line

At the actual summit, the trail leads through a narrow, rocky gap, and the whole scene is one of the most complete desolation, the naked granite rocks rising steeply to partly snow-clad mountains on either side. The slope of the pass on the north side is rather gradual, and the total ascent from the lake not very great, being but 1334 feet. To the south, on the contrary, it is at first abrupt and even precipitous, being accomplished over huge masses of fallen rock, which alternate here and there with steep, slippery surfaces of rock in place; but the travelling here is after all not so bad as that met with lower down the valley, where the trail goes through the woods along the steep, rocky and often boggy hillside, leading up and down the sides of several deep, narrow gullies. Two small detached glaciers occupy hollows in the slope of the mountains on the west side of this valley, and from these a considerable part of the water of the stream is derived. The "Stone house," or stone houses, and "Sheep camp" are points noted inthis part of the pass, the first consisting of several natural though inconvenient shelters, beneath great masses of rock which have rolled down from the mountain, where the Indians often stop over night; the second being the point where arboreal vegetation of fair growth first begins. Summit. South slope.

At six miles from the head of the inlet, the stream followed down from the summit is joined by another which has been dignified by the name of the Nourse River. A short distance up the valley of the latter, are somewhat extensive glaciers and high snow-covered mountains. Both the valley of this stream and that coming from the pass, are narrow and V-shaped, but from their point of junction, a wide flat- The Forks.

bottomed valley runs due south between high mountain walls and is continued further on in that occupied by the inlet itself. This valley is largely floored by gravel-flats and is evidently subjected at times to heavy floods. The little river formed by the confluence of these streams may be ascended with difficulty by canoes, for some miles, when the water is not low, but at the time we passed this was scarcely practicable. It is, however, easy to walk along the gravel-flats, the only discomfort being the necessity of fording the ice-cold and very swift water several times *en route*.

Taiya River.

Spring travel.

In the early summer, when the valleys on both sides of the summit are deeply filled with hard snow for a number of miles, the Indians secure a less abrupt grade (particularly on the south slope) by travelling on the snow and altogether avoiding the rough sides of the valley. This was the state of the pass when Mr. Ogilvie made his way inland over it in June. His greatest difficulty was found in connection with the Indians, who are untrustworthy and extortionate to a degree. He and his men were in consequence obliged to pack over a great part of their stuff themselves, and in so doing most of the party became snow-blind. He had with him two Peterborough boats, intended for use in his survey, and in safely transporting them across the Coast Ranges, accomplished a feat hitherto not attempted.

Rocks.

The rocks met with on the Chilkoot Pass are practically all granites, generally hornblendic and grey, though varying in coarseness of grain, and often porphyritic with pink orthoclase. The granite is cut in places by dark grey-green dykes, probably diabase. Near the actual summit it assumes a brecciated or shattered appearance, and here a considerable mass of coarse, black, and probably intrusive diorite occurs. In the valley south of the summit similar granites prevail, but in some places include rocks with pretty evident gneissic lamination, which were observed locally to pass into mica-schists. The gravel in the valley is also almost entirely composed of grey granite, though some specimens weather red on account of the quantity of pyrites they contain. Below the Forks, on the east side of the valley, the summits of several mountains show rocks evidently stratified, dipping at high angles. These are probably gneiss or schist, like those seen in the valley of the pass.

Glaciation.

Many rock-surfaces on both sides of the summit and up to the highest level of the pass were observed to be glaciated, and though no very certain evidence on this point could be obtained, it seemed probable that the ice had moved southward through the gap at the summit. The probable great accumulation of snow and ice on the north slope of the range might account for the parting-axis of the glacier lying to the north of the present actual water-parting.

Vegetation.

Scrubby hemlock (*Tsuga Pattoniana*) in a prostrate form occurs not far below the actual summit on both slopes. Below the "Stone house" this tree begins to become arboreal, and a few miles further down the valley, grows tall and straight, forming entire groves. Menzies spruce (*Abies Sitchensis*) also appears, a short distance below "Sheep camp," together with cottonwood (probably *Populus balsamifera*). Here also elder and birch were first seen on the south slope. The devil's club (*Fatsia horrida*) comes in about a mile above "Sheep camp." *Pinus contorta* was not seen till the Forks was reached.

Indian names.

The "Stone house" is named Te-hĭt by the Indians. The Indian name of the Taiya River of the maps, is Daī-ē'. Nourse River is named Kĭt-lĭ-koo-goo-ă', the stream followed southward from the summit of the pass Sī-tĭk'. These rivers are named Katlakúchra and Ssidrajĭk on the map of Dr. A. Krause.

The White Pass.

Character of the pass.

Having heard reports of the existence of a second pass from Taiya Inlet to the lakes on the head-waters of the Lewes, Mr. Ogilvie sent Capt. W. Moore to make an examination of it, with instructions to rejoin the party to the east of the mountains. This pass Mr. Ogilvie has named White Pass in honour of the late Minister of the Interior. It leaves the coast at the mouth of the Shkagway River* five miles south of the head of Taiya Inlet, and runs parallel to Chilkoot Pass at no great distance from it. Though the land carriage is somewhat longer by this pass, it appears to present less difficulty to the construction of a practicable trail or road. Some account of this pass, based on Capt. Moore's notes, is given in Mr. Ogilvie's preliminary report,† and additional particulars have since been obtained by correspondence with Capt. Moore. The distance from the coast to the summit is stated as seventeen miles, of which the first five miles is level bottom-land, thickly timbered. The next nine miles is in a cañon-like valley where heavy work would be encountered in constructing a trail. The remaining distance of three miles, to the summit, is comparatively easy. The altitude of the summit is roughly estimated at 2600 feet. Beyond the summit a wide valley is entered and the descent to the first little lake is said to be not more than one hundred feet. The mountains rapidly decrease in height and abruptness after the summit is passed, and the valley bifurcates, one branch leading to the head of Windy Arm of Tagish Lake, the other (down which the water drains) going to Tako Arm of the same lake.

* So named on chart in U. S. Coast Pilot, Schkague River of Krause.

† Annual Report of the Department of the Interior, 1887. Part ii, p. 64. See also Report by Moore to Chief Commissioner of Lands and Works of British Columbia, dated April 25th, 1888.

Other routes. The Chilkat Pass has already been noticed (p. 161 B). There is still another route into the interior, which the Indians occasionally employ in winter when the travelling is good over the snow. This leaves the Nourse or west branch of the Taiya and runs west of the Chilkoot Pass to the head of Lake Lindeman.

Exploration and Prospecting on the Lewes, and Gold Mining in the Upper Yukon Basin.

Various maps. The discovery and naming of the Lewes River by Campbell has already been referred to, (p. 138 B) but the information respecting the river obtained by the officers of the Hudson Bay Company during their short occupancy of Fort Selkirk, as embodied on Arrowsmith's map of 1854, was very incomplete, consisting merely of the fact that it divided into two main streams when followed up, and that large lakes existed on these. A considerable improvement is found in the delineation of the river on the map accompanying Dall's work on Alaska, (1870) in which information collected by the explorers of the Telegraph Survey is embodied, but the Lewes is there still merely outlined from report, and no approach to a reasonably correct map of its course existed up to the date of Schwatka's expedition in 1883. The first map of the Chilkoot and Chilkat passes and their vicinity is due, as mentioned further on, to Dr. A. Krause.

Indian jealousy. The passes connecting the coast with the interior country, from the heads of Lynn Canal to the upper waters of the Lewes, were always jealously guarded by the Chilkat and Chilkoot Indians of the coast, who carried on a lucrative trade with the interior or "Stick" Indians, and held these people in a species of subjection. Though the existence of these routes to the interior were known to the traders and prospectors, the hostility of the Chilkats and Chilkoots to the passage of whites long prevented their exploration.

Fables. In the Alaska Coast Pilot (1883, p. 278) it is stated on the authority of Captain J. C. Carroll, that the first transit of the Lewes River and Chilkoot Pass, by a white man, was accomplished in 1864 or 1865 by an employee of the Hudson Bay Company, who started from Fort Selkirk and was delivered by the Chilkoot Indians to Captain Swanson, then in command of one of the Company's steamers. This story is repeated and amplified in a work by Mrs. E. R. Scidmore, where the adventurer is designated as "a red-headed Scotchman" who "forced his way alone through the unknown territory to Chilkoot Inlet."*

I have endeavoured to verify this tale, but quite unsuccessfully, and while it is possible that some deserter from the Company's posts in

* Alaska, its Southern Coast and the Sitkan Archipelago. Boston, 1885.

the interior may thus have reached the coast, it is more probable that the story is entirely apochryphal. Enquiry made on the ground among the miners and others fails to substantiate it. Fort Selkirk had been in ruins for twelve years at the date referred to, and officers of the Hudson Bay Company who were on the coast at the time do not believe in its authenticity. It may, however, not improbably have grown out of the circumstance that a gun and some other articles which had belonged to Campbell's people at Fort Selkirk were, shortly after the raid upon that post, obtained from the Coast Indians by servants of the Company.

I have been able to find no reference to the discovery of gold in any part of the Yukon waters earlier than that given by Mr. F. Whymper, who writes in 1869: "It is worthy of mention that minute specks of gold have been found by some of the Hudson Bay Company's men in the Yukon, but not in quantities to warrant a 'rush' to the locality."* Discovery of gold.

The first white man who crossed from the coast to the head-waters of the Lewes appears probably to have been one George Holt†, who did so with the object of prospecting the country.‡ Holt.

The date of Holt's journey was, I believe, 1878. He was accompanied by one or more Indians, and crossed by the Chilkoot or by the White Pass to the head of the Lewes. He followed the river down to the lower end of Lake Marsh and walked over the Indian trail thence to the Tes-lin-too, returning to the coast again by the same route. On his return, he reported the discovery of "coarse gold," but none of the miners who afterwards prospected the region mentioned, have been able to confirm his statement in this particular. In the Alaska Coast Pilot the date of Holt's journey is given as 1875, and in the addendum to the same work as 1872§ in Mrs. Scidmore's book, already quoted, as "1872 or 1884." The date and route above assigned to Holt are, however, probably correct, being the result of enquiry among miners who knew him, followed his route through the country, and came in contact with the Indians whom he had met.

Some years later, in 1880, a prospecting party of nineteen men was organized at Sitka under the leadership of one Edward Bean. Amicable

* Travels in Alaska and on the Yukon. London, 1869, p. 227.

† Afterwards murdered by Indians at Cook's Inlet in 1885. Shores and Alps of Alaska, H. W. Seton Karr, London, 1887.

‡ U. S. Coast Pilot. Alaska, 1883, pp. 200, 278.

§ Other extraordinary journeys assigned to Holt in Mrs. Scidmore's book are, according to the miners, altogether incorrect. Holt appears to have been a romancer with considerable inventive powers, but it is possible that he made more than one journey. In May 1878, Messrs. Rath Bros, of Victoria, and Mr. Bean, of California, set out to cross by the Chilkoot Pass for the purpose of prospecting, but were not allowed to go inland by the Indians. Morris, Report upon the Customs District, etc., of Alaska, 1879, p. 97.

First prospecting party, 1880.

relations were established with the Chilkats and Chilkoots through the kind offices of Capt. Beardslee, U.S.N., and the Chilkoot Pass was crossed to Lake Lindeman. The party had, by this time, increased to twenty-five in number.* Boats were built on Lake Lindeman, and on the 4th of July the prospectors set out down stream. The Tes-lin-too was reached and was then, for the first time (and as it proves, erroneously,) recognized as the Hotalinqu. Before returning, the Tes-lin-too, was ascended and prospected for some distance. From George Langtry who was a member of the original party, and R. Steel, who joined it later, the facts, as above given, are derived.† No encouraging "prospects" were met with at this time, though Steel states that he found bars yielding at the rate of $2·50 a day in a small stream which joins the Lewes fifteen miles above the cañon.

This large party was closely followed by two miners known as Johnny Mackenzie and "Slim Jim," who reached Lake Lindeman on July 3rd. It is possible that other parties as well may have entered the country in this year, but if so I have been unable to trace them.

1881.

In 1881, a party of four miners, including G. Langtry and P. McGlinchey again crossed the Chilkoot Pass. These men got as far as the Big Salmon River, which they called the Iyon, by which name it is marked on the U. S. Coast Survey map of 1884. They ascended the Big Salmon, according to their estimate, about 200 miles, finding a little gold all along its course and meeting with some remunerative river-bars. This may be characterized as the first discovery of paying placers in the district. According to the U.S. Coast Pilot, already quoted, some account of this expedition is given in the New York Herald, of Sept. 21st, 1881, to which I have been unable to refer.

1882.

In 1882, a number of miners entered the Yukon country by the Chilkoot Pass, and probably during this season, but certainly not before,‡ two prospecting parties ascended the Pelly to Hoole Cañon and some of the men appear to have even gone some distance further up.§

Exploration by Krause.

Dr. Arthur Krause, engaged in an expedition on behalf of the Bremen Geographical Society, in May and June, 1882, made an explora-

* It had increased to twenty shortly after leaving Sitka. See Report by Capt. Beardslee, 47th Congress, 1st Session, Senate, Ex. Doc. No. 71, p. 65. In the same report, the names of the nineteen original members of the party are given and some account of its organization, etc.

† The account of the further wanderings of the party given in the U.S. Coast Pilot, Alaska (1883) p. 278 is incorrect.

‡ According to miners who were in the country at the time, the statements which have been published of earlier prospecting along the Upper Pelly are erroneous.

§ Through the kindness of Mr. François Mercier, I have obtained from Mr. D. Bertrand, who was a member of one of the parties above referred to, the names of the men composing both, as follows :—Thomas Boswell, John Dougan, Robert Robertson, D. Bertrand, Frank Densmore, John Riley, P. Cloudman, Robert Fox, Thomas Curney. The date, as above given is from Mr. Bertrand. Mr Boswell, whom we met on the Lewes in 1887, was understood to say that he had been prospecting up the Pelly in 1884 or 1885, but this statement probably referred to a subsequent expedition.

tion of the Chilkoot and Chilkat passes, reaching Lake Lindeman and the sources of the Tahk-heena River respectively. His work is embodied in maps published by the Bremen and Berlin Geographical Societies, and it is worthy of special note on account of its conscientious accuracy.*

Schwatka's journey.

In 1883, some mining was again in progress, but details respecting it have not been obtained. It was in this year that Lieut. Schwatka crossed the Chilkoot Pass and descended the Lewes and Yukon to the sea.† In 1884 a little mining was done on the Pelly and on the Tes-lin-too, and possibly also on the Lewes. In 1885, mining was begun along the Stewart River, and in the following year, the greater part of the mining population was engaged on that river. Cassiar bar, on the Lewes, twenty-seven miles below the Tes-lin-too, was discovered in the spring of 1886, and actively worked during the same summer.

Gold found on Forty-mile Creek.

Late in the autumn of 1886, "coarse gold" was found on Forty-mile Creek (Cone-hill River of Schwatka) still further down the main river than the Stewart, and the announcement of the fact drew off nearly the entire mining population to this place in 1887. In the attempt to bring out the news of this discovery, a miner named Williams was frozen to death on the Chilkoot Pass in January, 1887.

Lewes and Tes-lin-too.

Taking a general view of the gold discoveries so far as made in the Upper Yukon country, we find that, though some small bars have been worked on the upper part of the Lewes, and "prospects" have been obtained even in the stream flowing into Bennett Lake, paying bars have been found on this river only below the mouth of the Tes-lin-too. The best of these are within a distance of about seventy miles below this confluence, and the richest so far has been Cassiar Bar. This is reported to have yielded, in some cases, at the rate of $30 a day to the hand, and gold to the value of many thousand dollars has been obtained from it, chiefly in 1886. In 1887 only three or four men worked here. All along the Lewes below the Tes-lin-too, many bars occur which, according to the reports of prospector's, yield as much as $10 a day, and the same is true of the Tes-lin-too itself, both below and above Tes-lin Lake. Bars of this kind are, however, considered scarcely remunerative at present.

Cassiar Bar.

Salmon and Pelly.

Gold has also been found for a long distance up the Big Salmon River, and on the Upper Pelly as far as it has been prospected. The Tes-lin-too, Big Salmon and Pelly have each already afforded some good paying ground, but in consequence of the rush to Forty-mile Creek only about thirteen miners remained in 1887 on the first-named river, four

* Deutsche Geographische Blätter Bd. v Heft. 4, 1882. Zeitschr. des Ges. für Erdk. zu Berlin Bd. xviii, 1883.

† See Science vol. iii, 1884, also Report of a Military Reconnaissance in Alaska, Washington Government, 1885. Along Alaska's Great River, New York, 1885.

on the second, and two on the Pelly. On the Stewart River, as much as $100 a day to the hand was obtained in 1885 and 1886, and probably over $100,000 worth of gold has already been obtained along this stream. It has been prospected for a distance of 100 to 200 miles from its mouth, (according to varying statements) and the gold found furthest up is said to be somewhat "coarser" than that of the lower part.

Character of Forty-mile Creek.

Forty-mile Creek is reported to be a river of some size, but more rapid than most of those in the district. It has, according to miners, been prospected for about a hundred miles from its mouth, gold being found almost everywhere along it as well as in tributary gulches. The gold varies much in character, but is quite often coarse and nuggety, and very large amounts have been taken out in favourable places by individual miners. Few of the men mining here in 1887 were content with ground yielding less than $14 a day, and several had taken out nearly $100 a day for a short time. The amount obtained from this stream in 1887 is reckoned by some as high as $120,000, but I believe it would be safe to put the entire output of the Upper Yukon region for the year, at a minimum of $75,000, of which the greatest part was derived from this stream.

Miners.

The number of miners in the whole Upper Yukon country in 1887 may be stated at about 250; of these, 200 were on Forty-mile Creek, and it was estimated that at least 100 would winter on the creek to be ready for work in the spring.

Forty-mile Creek is what the miners term a "bed-rock creek" i.e., one in which there is no great depth of drift or detrital deposits below the level of the actual stream. It is so far the only locality which has been found to yield "coarse gold," but from the extremely wide distribution of "fine gold," it may safely be predicted that many more like it remain to be discovered.

General features of mining.

Mining can scarcely be said to have begun in the region more than five years ago, and the extent of country over which gold has been found in greater or less quantity is already very great. Most of the prospecting has been confined to the banks and bars of the larger rivers, and it is only when their innumerable tributary streams begin to be closely searched, that "gulch diggings" like those of Dease, McDame and other streams in the Cassiar district, and possibly even on a par with Williams and Lightning creeks in Cariboo, will be found and worked. The general result so far has been to prove that six large and long rivers, the Lewes, Tes-lin-too, Big Salmon, Pelly, Stewart and White, yield "fine gold" along hundreds of miles of their lower courses. With the exception of the Lewes, no part of the head-waters

of any of these have yet been prospected or even reached by the miners, and scarcely any of their innumerable tributaries have been examined. The developments made up to this time are sufficient to show that when means of access are improved, important bar-mining will take place along all these main rivers, and there is every reason to anticipate that the result of the examination in detail of the smaller streams will be the discovery of much richer auriferous alluviums. When these have been found and worked, quartz mining will doubtless follow, and the prospects for the utilization of this great mining field in the near future appear to me to be very promising.

I must not, however, omit to state that great difficulties and hardships have to be overcome by the miners now entering this country. Difficulties to be encountered The traverse of the Chilkoot Portage is itself a formidable obstacle, and over this pass most of the provisions and requisites for the miner must be carried. There is at the present time a trading post belonging to Messrs. Harper, McQuesten & Co., (established in the spring of 1887) at the mouth of Forty-mile Creek, but the supplies are brought to this point by small stern-wheel steamers which ascend the whole length of the Yukon. Goods do not arrive by this route till late in the summer, and any accident or detention may prevent their arrival altogether. The winter in the country is long and severe, and the season of low-water suitable for working on river-bars is short. It is also found that beneath its mossy covering, the ground is often frozen, presenting difficulties of another character to the miner, which have prevented the working of many promising flats and benches. This, however, is likely to be remedied before long by the general burning off of the woods and moss in the mining camps. Frozen ground was found in the same way in the early days of the Cassiar mines, (see p. 82 B) but the destruction of the timber has now almost everywhere allowed the summer heat to penetrate to the lower layers of the soil. It is not likely that this great inland country will long want some easy means of connection between the coast and its great length of navigable lake- and river-waters, and when this is afforded, there is every reason to believe that it will support a considerable mining population.

APPENDIX I.

NOTES ON THE DISTRIBUTION OF TREES AND OF CERTAIN SHRUBS IN THE YUKON DISTRICT AND ADJACENT NORTHERN PORTION OF BRITISH COLUMBIA.*

Some observations on the trees and plants noticed during the progress of the exploration here reported on, have been given in the preceding pages in connection with the localities described. In this note the general results obtained are presented in a connected form. A list by Prof. Macoun, including the names of all the species recognized, forms Appendix III.

The various lines traversed in the course of the exploration are included between 56° 30′ and 63° north latitude, the 128th and 138th meridians of west longitude. This area embraces the extreme northern part of British Columbia and adjacent regions of the North-west Territory, together with part of the "coast strip" of Alaska. Observations by the writer on the distribution of trees in the more southern portion of British Columbia, are contained in previous reports of this survey, particularly in that of 1879–80, which is accompanied by a map showing the limits of some of the more important species. Area included.

As already more fully stated, the region above defined is drained by the Stikine and other rivers, which flow through the Coast Ranges to the Pacific, by the Liard, a great tributary of the Mackenzie, and by several branches of the Yukon, but the several drainage basins do not mark out regions of diverse floras. The main division, from this point of view, is found as between the humid and comparatively uniform climate of the coast and the relatively dry and extreme climate of the interior, the first constituting the northern extension of the botanical region of the British Columbian coast, the second that of the interior of the same province. The dividing line is found along the higher ranges of the Coast Mountains. Character of the region.

The considerable altitude of the interior region also has its influence on the flora, but within the limiting parallels above stated, difference of latitude produces a comparatively small effect, in consequence of the

* The facts included in this note were published substantially in their present form in Garden and Forest, vol. i, No. 5, March 28. 1888.

fact that the country as a whole becomes lower to the northward or north-westward.

The chief facts to be recorded with respect to the distribution of trees are those connected with the northern limits of the well-known West Coast species, the total number of arboreal forms represented so far north being quite restricted.

Trees of the interior.

In the interior, which may be treated as a whole, the Douglas fir (*Pseudotsuga Douglasii*), Engelmann's spruce (*Picea Engelmanni*), the hemlock (*Tsuga Mertensiana*) and the red cedar (*Thuya gigantea*), all common and characteristic trees a few degrees of latitude to the south, are nowhere found. The white and black spruce (*Picea alba* and *P. nigra*), balsam-fir (*Abies subalpina*), aspen (*Populus tremuloides*) and cottonwood (*Populus trichocarpa*, probably with *P. balsamifera*), are found in suitable localities over the whole region east of the Coast Mountains, the two first-mentioned trees constituting probably half the entire forest covering of the country.

Ubiquitous species.

The white spruce, along the rivers and in sheltered valleys and low ground, everywhere forms fine groves to the furthest northern point reached, many trees attaining a diameter of two feet, tall and well grown. It affords lumber of very fair quality,—the best to be obtained in the country. It is found, with *Abies subalpina*, at the highest limit of timber,—about 4200 feet,—on the inland mountains. The black spruce has scarcely received mention in previous notes on the distribution of trees in British Columbia, but is now known to be abundant locally on high plateaux about the region of the Upper Fraser, and in the country here specially described, grows, mingled with the white spruce, in swampy situations and along cool, shady and damp river-banks. It attains a considerable height, but is never large enough to afford good lumber. *Abies subalpina* was found wherever the upper limit of trees on the mountains was approached, but was not observed near the rivers, except on Bennett Lake (2150 feet), near the head-waters of the Lewes River, in latitude 60°, where it becomes very abundant. The aspen is specially characteristic of second-growth woods and of dry, open, grassy hill-sides facing to the southward, of which there is a great extent on the Upper Pelly and Lewes. The cottonwood here represented is, so far as the specimens brought back can be determined, *Populus trichocarpa*, but there is little doubt that the balsam-poplar also occurs. Specimens six feet in diameter were seen on the Stikine River near the Coast Mountains, but further in the interior the tree is rarely large enough for the manufacture of dug-out canoes, or, say, three feet in diameter.

Greater interest, from a botanical point of view, attaches to the trees of which the ranges are more restricted. The black pine (*Pinus Mur-*

rayana), perhaps the most common and characteristic tree of the whole interior of British Columbia, is also pretty widely distributed in this northern region. It is found in abundance on the Stikine, near the Little Cañon, on the eastern side of the Coast Mountains, and thence inland, in suitable localities. It was observed on the Dease and Upper Liard, and from the mouth of the Dease (according to specimens sent back by Mr. R. G. McConnell) extends down the Liard to Devil's Portage, some miles east of the range which appears to represent the northern continuation of the Rocky Mountains proper. Beyond this point the Banksian pine becomes characteristic of the great valley of the Mackenzie, which is here entered, but this tree does not extend to the west of the Rocky Mountains. On the head-waters of the Liard *Pinus Murrayana* reaches nearly to Finlayson Lake, its most northern source, but does not occur on the Upper Pelly, on descending which it was first met with in long. 133° 30′. From this point down the Pelly and up the whole length of the Lewes to its sources at the base of the Coast Mountains, it was constantly noted, becoming quite abundant near the Lewes head-waters. Mr. W. H. Dall gives the mouth of the Lewes (lat. 62° 47′) as the northern limit of this tree.* Cones were brought back from this place by Ketchum, of the Telegraph Survey party, which were sent by Mr. F. Whymper to Sir J. Hooker, who determined them. (Under the name of *P. contorta*, from which *P. Murrayana* was not at that date separated.) Black pine.

My own observations did not extend to the north of this point, down the river, but Mr. McConnell, who has since examined the lower river, states that this tree does not occur at Forty-mile Creek, and that he did not observe it till he reached the vicinity of old Fort Selkirk, in ascending the stream, thus confirming Mr. Dall's remark.

The known range of the common larch (*Larix Americana*) has, by the observations here reported on, been carried to the west of the Rocky Mountains. This tree extends westward on the Dease River to a point twenty-two miles above its mouth, and along the Liard and Frances rivers spreads northward nearly to Finlayson Lake, reaching latitude 61° 35′. Between the limits thus defined it is quite abundant, and characteristic of cold, swampy tracts and northern slopes, where it grows with the black spruce. It was looked for all along the Pelly, but nowhere found either on this river or on the Lewes. It appears quite probable, however, that this tree will eventually be proved to characterize the sub-arctic country, further to the north, from the Mackenzie valley nearly to the shores of Behring Sea, as Dall refers to the presence of a larch in several places on the Lower Yukon (under Larch.

* Alaska and its Resources, pp. 441-592.

the names *L. microcarpa* ? and *L. Davurica* ?),* which can scarcely be any other than this species. *Larix Lyallii*, which, about the 49th and 51st parallels in the Rocky Mountains, is the most characteristic tree at the timber-line, was not anywhere seen in the region now in question, and would therefore appear to be a relatively southern mountain species.

Birch. The birch (*Betula papyrifera*) was first seen on leaving the coast by the line of the Stikine, near Kloochman Cañon, thirty miles below Telegraph Creek, some trees here being two feet in diameter. It was also seen on the Dease River, and on the Liard head-waters northward to Frances Lake, where it is abundant, but does not occur on the Upper Pelly till a point a few miles beyond the 131st meridian is reached. Below this, along the Pelly, it is found with increasing frequency, and also occurs here and there on the Lewes, though its limit toward the head-waters of this stream was not noted. The birch never in this region forms extensive groves, but grows singly or in small groups among other trees. It is also found on the Yukon far below the confluence of the Porcupine.

Dwarf birch. *Betula glandulosa*, though only a shrub, may be mentioned here, and probably occurs throughout the entire region. It was first noted on the trail between Telegraph Creek, on the Stikine, and Dease Lake.

Juniper. The juniper (*Juniperus Virginiana*) was observed as a small tree, with trunk six inches in diameter, in the dry country in the lee of the Coast Mountains at Telegraph Creek on the Stikine, (540 feet), but is not elsewhere arboreal.

Alder. The alder, (probably *Alnus rubra*) and one or more species of willows, become small trees along some of the rivers of the interior. The alder was noted as specially abundant and large on the Upper Pelly.

Service-berry. The service-berry (*Amelanchier alnifolia*), as a low shrub, was also noted in the vicinity of Telegraph Creek, and was there in full flower on May 24th. It was again seen, to the east of the Cassiar Mountains, in the valley of the Dease (about 2400 feet), on June 22nd, somewhat more advanced than at the first-mentioned locality, but still, in the stage of growth to which it had attained at this date, indicating a comparatively retarded summer in this locality. It does not occur on the Upper Liard or the Pelly, and was only once again observed, on Tagish Lake (2150 feet), at the head of the Lewes; here also in the dry lee of the Coast Ranges. It is here in latitude 60° 15′, which is believed to be the furthest northern point from which this species has been recorded to the west of the Rocky Mountains. From observations made in the Peace River region, and elsewhere in British Columbia, it appears that the northern range of this species nearly coincides with that of

* Alaska and its Resources, pp. 29-441.

the growth of wheat, and it is interesting to note, in connection with its appearance at Telegraph Creek, that wheat can actually be grown and ripened there, under the 58th parallel. *Elæagnus argentea* was also noted at Telegraph Creek, but was not again seen till near the mouth of the Lewes, on the Pelly River. In ascending the Lewes it was observed in several places, and always indicates a rather dry climate.

Timber-line.

As already stated, the timber-line, or upper limit of the growth of forest, on the mountains of the interior, in the vicinity of the watershed between the Liard head-waters and those of the Pelly in lat. 61° 30′, was found to be at about 4200 feet. At a similar distance from the Pacific Coast, in the corresponding range of the mountains, in lat. 51° 30′, the same line is found at about 7000 feet, showing a descent to the north of 2800 feet in ten degrees of latitude, or about 280 feet in each degree.

Change due to latitude on the coast.

It is generally stated that the influence of the warm waters of the Pacific Gulf Stream, striking the northern part of the West Coast and flowing southward along it, is such as to produce a nearly similar climate and flora from the Straits of Fuca far to the north. While this is true in a general way, it is a mistake to suppose that no effect is produced by the increasing latitude. The most marked change of climate, as indicated by the arboreal vegetation, nearly coincides with Dixon Entrance, on the 54th parallel. The forest north of this point is generally inferior in growth, and the quantity of marketable timber is much smaller. The red cedar (*Thuya gigantea*) is not found in any abundance north of the latitude of the mouth of the Stikine River, and though closely looked for along the coast in the vicinity of Lynn Canal, no single specimen of it was detected there. It is confined to the mouth of the Stikine River, and does not follow up this low valley for any distance inland. The yellow cedar (*Thuya excelsa*) scarcely reaches Sitka, and is not anywhere found among the inner islands near the entrance to Lynn Canal. The alder (*Alnus rubra*) forms groves along the shore at least as far north as latitude 59°. The western crab-apple (*Pyrus rivularis*) occurs here and there as far north as Lynn Canal. The broad-leaved maple (*Acer macrophyllum*) may reach latitude 55° on the Alaskan coast, as stated by Prof. Sargent,* but was not observed by me, and must be quite rare. North of the Prince-of-Wales Archipelago, eight-tenths of the entire forest of the coast region consists of the single species, Menzie's spruce (*Picea Sitchensis*). *Pinus contorta* was noted at the head of Lynn Canal and elsewhere along the coast. Here also, in the valley of the stream on the south side of the Chilkoot Pass, by which the Coast Mountains are crossed, *Tsuga Pattoniana* grows to a fair size. It is found also within a few hundred

Northern limits of certain trees.

* Report on the Forests of North America, U. S. 10th Census, p. 47.

feet of the summit of the pass, at an altitude exceeding 3000 feet, in a prostrate form, but still frequently bearing cones. *Abies amabilis* (?) was noted in the valley of the west slope of the pass, and occurs along Lynn Canal and elsewhere on the coast.

The devil's-club (*Fatsia horrida*), a plant most characteristic of an atmosphere saturated with moisture, is not anywhere seen in this part of the interior country, but was met with in the valley to the west of the Chilkoot Pass, and ascends the Stikine valley to a point a few miles above the Kloochman Cañon.

NOTE.—The approximate limits of several species of trees, etc., are indicated on the Index Map attached to this report.

APPENDIX II.

NOTES ON THE INDIAN TRIBES OF THE YUKON DISTRICT AND ADJACENT NORTHERN PORTION OF BRITISH COLUMBIA.

Region included.

Such information as I have been able to obtain during our journey respecting the Indian tribes of the extreme northern portion of British Columbia and the adjacent Yukon District, are given in the following pages. Between the northern edge of the ethnological map of British Columbia prepared by Dr. Tolmie and myself in 1884,* and the known portion of the area of Mr. W. H. Dall's similar map of Alaska and adjacent regions,† a great gap has existed, which I had proposed to endeavor to fill in connection with the work of the Yukon Expedition. While this intention has been very imperfectly executed, owing to various causes not necessary here to particularize, but especially to to the fact that during a great part of our journey we met with neither Indians nor whites from whom information might have been obtained, it is felt that any facts on the Indians of the district possess some value, not alone from a scientific point of view, but also in their bearing on the Indian question from an executive standpoint.

Inland and Coast Indians.

Throughout the more southern portion of British Columbia, a difference of the most marked kind is everywhere found as between the maritime Indians of the coast and the inland tribes. While this difference is largely one of habit and mode of life, it is also almost everywhere coincident with radical differences in language; the natural tendency to diversity as between coast-inhabiting fishermen and roaming hunters being intensified and perpetuated by the great barrier of the Coast Ranges. Only upon certain routes of trade which have existed between the coast and the interior is this striking diversity to some extent broken down. The Fraser, the Skeena, the Nass and—in the region here specially referred to—the Stikine and the passes at the head of Lynn Canal, constitute the most important of these routes.

Thlinkit.

From Dixon Entrance northward, with the exception of certain small outlying colonies of the Haida on Prince-of-Wales Island, the

* Comparative Vocabularies of the Indian Tribes of British Columbia, 1884.

† Contributions to North American Ethnology, Vol. i.

Coast Indians are undoubted Thlinkit, forming a series of contiguous and more or less closely allied bands or tribes, between which the diversity in language is small. The inland Indians, on the contrary, belong to the great Tinné family. On the Stikine, as explained below, a certain overlapping of these two races has occurred; and to the north, the Tagish, a branch of the Thlinkit, extend a considerable distance inland into the basin of the Lewes, as now first ascertained. The interior Indians are collectively known on the coast as "Stick Indians," and the fact that this name is also applied to the Tagish, in consequence of their situation and habits being like those of the Tinné, explains the circumstance that they have heretofore been confounded with that people.

Tinné. Respecting the Thlinkit of the coast I am unable to add anything of value to what has already been published. In what follows regarding the inland Indians, the several tribes are taken up in the order in which they were met with on our line of travel.

The region included between the Coast Ranges and the Rocky Mountains, to the south of that here reported on, and in which are the head-waters of the Skeena, Fraser and Peace rivers, is inhabited by two great divisions of the Tinné people, designated on the map before referred to, as Takulli and Sikani. These main divisions comprise a large number of small tribes or septs. Since the publication of the map, I have ascertained that these divisions are known to the people themselves as Tah-khl and Al-ta'-tin respectively. The division of the Tinné met with on ascending the Stikine is named Tahl-tan, and consists of the Tahl-tan people proper and the Taku. These Indians speak a language very similar to that of the Al-ta'-tin, if not nearly identical with it, and, so far as I have been able to learn, might almost be regarded as forming an extension of the same division. They appear to be less closely allied by language to the Kaska, with which people they are contiguous to the eastward.

Tahl-tan Indians.

Their territory. The Indian village near the Tahl-tan or First North Fork of the Stikine, is the chief place of the Tahl-tan Indians, and here they all meet at certain seasons for feasting, speech-making and similar purposes. The Tahl-tan claim the hunting-grounds as far down the Stikine, coastward, as the mouth of the Iskoot River, together with all the tributaries of the Iskoot and some of the northern sources of the Nass, which interlock with these. Their territory also includes, to the south, all the head-waters of the main Stikine, with parts of adjacent northern branches of the Nass. Eastward it embraces Dease Lake, and goes as far down the Dease River as Eagle Creek, extending also to the west branch of the Black or Turnagain River. It includes also all the northern tributaries of the Stikine, and the Tahl-tan River to its sources.

Taku Indian

The Taku form a somewhat distinct branch of the Tahl-tan, though they speak the same dialect. They are evidently the people referred to by Dall as the Tăh'-ko-tin'-neh.* They claim the whole drainage-basin of the Taku River, together with the upper portions of the streams which flow northward to the Lewes; while on the east their hunting-grounds extend to the Upper Liard River, and include the valleys of the tributary streams which join that river from the westward. They are thus bounded to the south by the Tahl-tan, to the west by the coast Taku (Thlinkit), to the north-west by the Tagish, and to the east by the Kaska.

Rights of coast and inland tribes.

The territorial claims of the Tahl-tan and Stikine Coast Indians (Thlinkit) overlapped in a very remarkable manner, for while, as above stated, the former hunt down the Stikine valley as far as the Iskoot, and even beyond that point, the latter claimed the salmon-fishery and berry-gathering grounds on all the streams which enter the Stikine between Shĕk's Creek (four miles below Glenora) and Telegraph Creek, excepting the First South Fork, where there is no fishery. Their claim did not include Telegraph Creek nor any part of the main river; nor did it extend to the Clearwater River or to any of the tributaries lower down. In whatever manner the claim to these streams may have been acquired, the actual importance of them to the Coast Indians lay in the fact that the arid climate found immediately to the east of the Coast Ranges enabled them to dry salmon and berries for winter provision, which is scarcely possible in the humid atmosphere of the coast region.

The strict ideas entertained by the Indians here with respect to territorial rights is evidenced by the fact that the Indians from the mouth of the Nass, who have been in the habit of late years of coming in summer to work in the gold mines near Dease Lake, though they may kill beaver for food, are obliged to make over the skins of these animals to the local Indians. Thus, while no objection is made to either whites or foreign Indians killing game while travelling, trapping or hunting for skins is resented. In 1880 or 1881 two white men went down the Liard River some distance to spend the winter in trapping, but were never again seen, and there is strong circumstantial evidence to show that they were murdered by the local Indians there.

Trade between coast and interior.

On the Stikine, as in the case of other rivers and passes forming routes between the coast and the interior, the Coast tribes assumed the part of middle-men in trade, before the incursion of the miners broke up the old arrangements. The Stikine Indians allowed the Tahl-tan to trade only with them, receiving furs in exchange for goods obtained on the coast from the whites. The Tahl-tan, in turn, carried on a

* Contributions to North American Ethnology, vol. i.

similar trade with the Kaska, their next neighbors inland. The right to trade with the Tahl-tan was, in fact, restricted by hereditary custom to two or three families of the Stikine Coast Indians.

Houses. With the exception of the houses already referred to as constituting the Tahl-tan village, and some others reported to exist on the Taku, the residences and camps of these people are of a very temporary character, consisting of brush shelters or wigwams, when an ordinary cotton tent is not employed. We noticed on the Tahl-tan River a couple of square brush houses formed of poles interlaced with leafy branches. These were used during the salmon-fishing season. At the same place there were several graves, consisting of wooden boxes or small dog-kennel-like erections of wood, and near them two or three wooden monumental posts, rudely shaped into ornamental (?) forms by means of an axe, and daubed with red ochre.

Chief's name. On attaining the chieftaincy of the Tahl-tan tribe, each chief assumes the traditional name Na-nook, in the same manner in which the chief of the Coast Indians at the mouth of the Stikine is always named Shĕk or Shake.

Superstitions. The Tahl-tan Indians know of the culture- or creation-hero Us-tas, and relate tales concerning this mythical individual resembling those found among the Tinné tribes further south, but I was unable to commit any of these to writing. Amongst many other superstitions, they have one referring to a wild man of gigantic stature and supernatural powers, who is now and then to be found roaming about in the summer season. He is supposed to haunt specially the vicinity of the Iskoot River, and the Indians are much afraid of meeting him.

Character of wars. Between the Tahl-tan and the Indians inhabiting the Upper Nass* there has been a feud of long duration, which is even yet outstanding. There is much difficulty in settling such feuds when life has once been sacrificed, as they assume the character of a vendetta, a strict account being kept, which must be balanced by the killing of an equal number on each side before lasting peace is possible. The account of the feud here referred to is derived from Mr. J. C. Callbreath, who has been at some pains to ascertain the circumstances. It may serve to illustrate the nature of the intertribal "wars" carried on in the sparsely inhabited region of the interior.

* We are unfortunately without precise information as to the tribal divisions of the Indians of the Nass. According to the late Dr. Tolmie, who had long resided at Fort Simpson, in the vicinity of the Nass, the people about the mouth of the river are named Niska (sometimes written Naskar), while further up the river are the Nitawălik (Tinné?). (Comparative Vocabularies, p. 113 B.) It is probably the people so designated who come in contact with the Tahl-tan, but in the meantime I prefer to call them merely Nass Indians. The statement above quoted, however, does not tally with that made to G. Gibbs by Celestine Ozier, a Tshimsian half-breed, i.e., that to the northward of the tribe inhabiting the Nass was a tribe named Nis-kah. (Contributions to North American Ethnology, vol. i, p. 143.)

For a long period preceding 1856 there had been peace between the Tahl-tan and Nass Indians, but in or about that year the latter, following up one of the branches of the Nass River into Tahl-tan territory, killed two individuals of that tribe, who happened to be men of importance. Two or three years later, the Tahl-tan found an opportunity of killing in retaliation four of the Nass. In 1861, the year preceding the first gold excitement on the Stikine, a peace having been meanwhile concluded, the Nass Indians induced some of the Tahl-tan to visit them in their own country, a short distance from the recognized boundary, at a place named Yak-whik, which is the furthest up fishery of the Nass Indians, and at which they have a large house. The Nass people then persuaded two of the Tahl-tan men to return some distance into the Tahl-tan country, ostensibly that they might bring their friends to engage in a peace talk and dance, two of the Nass Indians accompanying them. The Nass, however, killed both Tahl-tan Indians the first night out, and then turned back. When they arrived at the house, the remaining Tahl-tan men were killed and their women (seven in number) and children (three boys) were made prisoners. Two of the women, with one of the boys, however, escaped and eventually found their way back to their friends. Another of the women was afterwards brought up the Stikine and redeemed by her people. Two more have since died in the Nass country, and one still remains there as a slave. The last event in connection with this feud occurred in 1863 or 1864, when the Tahl-tans raided into the Nass country and waylaid a man and woman with three children. The adults, with two of the children, were left for dead, but the man afterwards recovered consciousness and managed to get home. One of the children was not harmed and has since grown to manhood, and is known to be meditating revenge on the Tahl-tan people. **Feud between Tahl-tan and Nass.**

Notes on the Tahl-tan Indians by Mr. J. C. Callbreath.

The following account of the principal characteristics of the Tahl-tan Indians has been kindly drawn up at my request by Mr. J. C. Callbreath, who has spent many years among these people. The general order followed is that of the Circular of Enquiry issued by the Committee of the British Association on the North-western tribes of the Dominion of Canada. In transcribing Mr. Callbreath's notes some unimportant verbal alterations only have been made.

Maximum stature about 5 feet 7½ inches. Maximum girth about the chest 37 inches. Legs and thighs well muscled. Arms rather light. As a rule full chested. Heads, unlike the coast tribes, small. Feet and hands generally small, as are also the wrist and ankle, especially **Measurements.**

in the women. We sell more No. 2 women's and No. 6 men's shoes than any other size [representing a length from toe to heel of 8⅝ inches and 10 inches respectively]. In hats for the Indian trade we take nothing above No. 7 [equal to circumference of 22 inches].

The trunk is generally long and the legs short,—the former nearly always straight, with small waist and broad hips, the latter usually curved or crooked, a circumstance which appears to be due to too early walking and carrying packs by the children. Brain-capacity small, head round, forehead low and bulging immediately above the eyes, but generally broad.

Half-breeds. The half-breeds are more like the father, and three generations where the father is in every case white, seem to obliterate all trace of Indian blood. If the case were reversed and the male parent in all cases an Indian, the result might be different. Have never seen or heard of an albino among them. Their most common ailments are pulmonary consumption and indigestion. The former caused by careless and unnecessary exposure, the latter by gorging and drinking at their periodical feasts. They have other diseases peculiar to themselves, induced, as I believe, by imagination or through fear of the medicine-men or witches.

Diseases.

Acuteness of senses. Their acuteness of sight, hearing and smell are great, but I do not believe racial. Practise and training as hunters, render them proficient in these respects. Their eyes fail early, and are even more liable to disease than those of whites. It is rare to meet a man of fifty among them with sound eyes. Snow and sun together, with smoky dwellings, probably explain this. The children are cunning and clever when young, more so than those of the white race, but grow dull as they age.

Language. I have never seen anything like gesture-language among them, and will not attempt a description of their common tongue, except to say that I can see no similarity in it to that of the Chinese, with whom I have had intercourse to a considerable extent for the past forty years.

Stone implements. They reckon time by moons, and now seem to rely more on what the whites may tell them as to the coming of winter or spring, than on their own knowledge. The stone age is now scarcely more than a tradition, though they know of the time when they had no iron, axes, knives, guns or the like. Stone knives, adzes, and sledges or hammers, have been found by the miners from time to time, and it is said that the sledges were used for killing slaves on certain occasions, as well as for braining bears in their hibernating dens.

Weaving. I cannot learn that these Indians ever used copper before its introduction by the whites. Yarn is spun from the wool of the mountain goat (not the mountain sheep or big-horn) and is woven into excellent

blankets which are highly coloured and ornamented. The process of boiling water with hot stones in baskets or wooden bowls was formerly common.

The dances of the Tahl-tan are tame affairs compared with those of the Coast tribes. Masks representing birds or bears are sometimes worn on these occasions. Their musical propensities and capabilities are, however, considerable. In their dances they use the common Indian drum, known all over the continent. No athletic games are practised. Kinship, so far as marriage or inheritance of property goes, is with the mother exclusively, and the father is not considered a relative by blood. At his death his children inherit none of his property, which all goes to the relatives on his mother's side. Even though a man's father or his children might be starving, they would get none of his property at his death. I have known an instance where a rich Indian would not go out or even contribute to send others out to search for his aged and blind father who was lost and starving, in the mountains. Not counting his father as a relative, he said,—"Let his people go and search for him." Yet this man was an over-average good Indian. They seem to have no inherent good qualities which will overcome the vicious and unnatural rules and customs of their tribe. Although the son thus, in many cases, seems to have no regard for his father, the latter generally has a parent's love for the son, and desires to see him do well. Dances. Kinship.

The whole tribe is divided into two casts, *Birds* and *Bears*. A man who is a Bird must marry a Bear and his children belong to the Birds, but the Bears, his mother's people, inherit all his effects. The right to hunting-grounds is inherited. A Bear marrying a Bird may go to the Birds hunting-ground, that is to the hunting-ground belonging to the particular family of Birds into which he has married, or he may stay on his own hunting-ground belonging to his particular Bear family, which he inherited from his mother. His children, however, by his Bird wife or wives, after becoming adult, cannot resort to his hunting-ground. His children, both male and female, being Birds, must marry Bears. They might, if males, marry his full sister, who being a Bear is not counted a relative, and thus, through her, inherit a right to her father's old hunting-ground. In some cases, when such proprietary rights are valuable, and the father is anxious that his son should be able to claim the old homestead or hunting-ground, such an arrangement is made. The son may be eighteen and his father's sister (his aunt) may be fifty, but such disparity in age is of no consequence at all. The son's wish is to secure his title. He may forthwith take another young wife to please his fancy. Totems.

Marriage.

A man's female children are as much his property as his gun and he sells them to whom he pleases without consulting their feelings at all. The vendor sometimes gets his pay at once, sometimes by installments, and if the installments are not paid, he may take back his daughter with her children as well. If, however, the husband pays for his wife in full, the vendor is held strictly to his bargain in respect to supplying a wife, and should the first die and he have any more eligible daughters, one of these must take her place, and that without any additional compulsory payment. Thus, for instance, a man of fifty may buy a young wife of fifteen (a not uncommon occurrence) and pay for her in full. Ten years afterward the young wife may die, and if there be another unsold sister, that sister, according to their laws, must take her place without any compensation, unless it be voluntary. The husband always evinces a high regard for his wife's parents and never tires, if able to do so, of making them presents.

Chieftaincy.

A chief's son has no right to his father's title or any claim to rule by virtue of his being the son of the chief, although the tribe may choose him as their chief. A chief's brother (full or half) or his sister's child, is the legal heir, but his right must be sanctioned by a majority of the tribe, and the office frequently passes to whoever has most property to give away.

Customs and laws.

All the Indians are very miserly, and they often go hungry and naked for the purpose of saving up blankets, guns, etc., with which to make a grand "potlatch" (donation feast) to their friends. This secures them consideration and a position in the tribe. Practically very few of the men have more than a single wife. When a man has two wives, the younger, if she be sound and lively, is the head. Separation and divorce is easy and requires no formal act, but if a man should send away his wife, on whose hunting-grounds he may have been staying, he must leave her inherited hunting-ground, unless he has another wife who has a right to the same ground. These hunting grounds are extensive and are often possessed in common by several families.

The laws are based on the principle that any crime may be condoned by a money payment. If a man should kill another, he or his friends must pay for the dead man—otherwise he himself or one of his friends must be killed to balance the account.

The vicious and unnatural practices of these people appear to be traceable in all cases to the teaching of their medicine-men or witches, in whom they believe implicitly. Their religious belief was simply what their medicine-men might lay down for them from time to time, the idea of a Supreme Being, being very obscure, if not altogether wanting.

They have no war chiefs, and I cannot find that they ever had a general war with any other tribe. Some families have had and are yet having trouble with families of other tribes whom they claim encroach on their hunting-grounds. These families fight it out among themselves by waylaying and murdering each other, but there it ends without producing any inter-tribal war. Wars.

Gratitude and charity seem to be foreign to the natures of these people. A man often gives away all he has to his friends, but it is for purposes of personal aggrandizement, and his father, mother or sister may be sick, freezing or starving within sound of his voice. His presents bestowed upon those who are strong and above want bring him distinction, which is his only object. The young Indians are, however, more humane and charitable than the aged. Manners and traits.

The Tahl-tan Indians have no totem-poles, although they preserve the family lines, and observe them as strictly as do the salt-water tribes. They have no fear of death except from dread of the pain of dying, and this is very much lessened if they have plenty of goods to leave to their friends. They are very stoical, and not emotional, in any sense. I have never seen one of them tremble or quake with fear or anger. There is a belief propagated by their medicine-men or witches that the otter gets inside of their women and remains there until death, sometimes causing death by a lingering illness unlike anything I have ever seen, in other cases allowing the woman to live on till she dies from some other cause.

The name Kaska (from which that of the district Cassiar is derived*) is applied collectively to two tribes or bands occupying the country to the eastward of the Tahl-tan. I was unable to learn that this name is recognized by these Indians themselves, and it may be, as is often the case with names adopted by the whites, merely that by which they are known to some adjacent tribe. It is, however, a convenient designation for the group having a common dialect. This dialect is different from that of the Tahl-tan, but the two peoples are mutually intelligible and to some extent intermarried. The Kaska are still more closely allied by language and marriage to the Indians of the Lower Liard, who are commonly referred to as the "Hudson Bay Indians," from the circumstance that they trade with that company. Practically the whole of the Kaska trade either at McDame Creek or at the little outpost at the mouth of the Dease. The entire number of Indians re- Kaska Indians.

* Mr. J. W. McKay states, in answer to a question addressed to him on that subject, that Cassiar is a corrupt spelling of the word Kaska. Mr. McKay further adds that he has a suspicion that the word Kaska is connected with that *kaska-met* used by the Stuart Lake Indians to designate dried beaver meat, though he has been unable to confirm this.

sorting to the first named place is 70. That at the mouth of the Dease 94, made up of 23 men, 18 women, and 53 children. The aggregate number of the Kaska, who inhabit a vast territory, is thus very small.

Boundaries.

To the westward, the Kaska are bounded by the Tahl-tan. They hunt over the country which drains to the Dease east of McDame Creek; but north of the sources of streams reaching the Dease, they wander seldom, if at all, to the west of the Upper Liard. They also hunt over the basin of the Black or Turnagain River, southward, but not to the head-waters of that stream, as the country there is claimed by the Al-ta'-tin ("Siccanie") of Bear Lake region, who have lately returned to it after having abandoned it for a number of years. Eastward they claim the country down the Liard to the site of Old Fort Halkett, and northward roam to the head of a long river (probably Smith River) which falls into the Liard near this place, also up the Upper Liard as far as Frances Lake, though it would appear that not till recent years have they ventured so far in that direction.

Composed of two tribes.

The two cognate tribes here referred to collectively as the Kaska are named respectively, by themselves, Sa-zē-oo-ti-na and Ti-tsho-tĭ-na. The first occupy the corner between the Liard and Dease, above referred to, as well as the country southward on Black River, where they meet the Bear Lake Indians, named by them Sat-e-loo'-ne. The Ti-tsho-tĭ-na claim the remaining eastern half of the Kaska country, and call the Indians further down the Liard, below Fort Halkett, A-tsho-to-tĭ-na.* These are no doubt the tribes referred to by Dall (following a manuscript map by Mr. Ross, of the Hudson Bay Company) as the Achē'-to-tin'-neh and Dābo'-tenā' respectively.† The latter are, however, I believe, distinct from the "Siccanie" or Al-ta'-tin proper. The number stated for the Indians trading at the mouth of the Dease, probably includes some individuals properly referable to the tribe just mentioned. The Indians from Pelly River also sometimes come to the same place to trade, but are not included in the enumeration, and occasionally a few Taku or Tagish wander so far, following the trail eastward from Lake Marsh on the Lewes.‡

Names of the tribes.

The Ti-tsho-tĭ-na call the Pelly River people Ta-koos-oo-ti-na and designate those beyond there again by the term Ai-ya'-na.

Characteristics.

The Kaska have the reputation of being a very timid people, and they are rather undersized and have a poor physique. They are lazy and untrustworthy. We met practically the entire tribe of the Ti-

* Erèttchi-ottinè or Ndu-tchô-ottinè (?) of Petitot in Bul. Soc. Geog., 1875.

† Contributions to North American Ethnology. vol. I.

‡ Mr. Campbell, in answer to my enquiries, states that there were no leading tribes, under chiefs, in his time on the Upper Liard, but scattered family bands only. These included the "Bastard" tribe or family, the "Thlo-oo-chassies" and the "Nahanies of the Mountains," the last-named trading indifferently on either side of the mountains, but being quite a different race from the Nahanies of the Stikine (Tahl-tan).

tshu-tī-na at the little post at the mouth of the Dease, and their curiosity proved to be very embarrasing. Mr. Egnell, who was in charge of the post, excused it by explaining that they had never seen so many Whites together before, the number being nine in all, including our party, Mr. Egnell himself and Mr. McDonald, of the Hudson Bay Company. Of these Indians, only two had been as far west as Dease Lake, and none had ever seen the sea. They are, however, fairly well off, as their country yields abundance of good furs. They visit the trading post only once in the course of the year, spending the remainder of their time moving from camp to camp in isolated little family parties, hunting and trapping; each one traversing a very great extent of country in the course of the twelve months. Some of their traps or household goods are packed on dogs, but the greater part of their impedimenta is carried by themselves on their backs, canoes being seldom employed. Rivers and lakes are crossed in summer by rafts made for the occasion. They generally bring in only the fine furs, as bear-skins and common furs are too heavy to transport. They evidenced great curiosity with regard to our equipment, being particularly struck by a canvas boat and an air pillow. These and other objects, I have no doubt, furnished subjects of conversation round many camp fires for the ensuing year. **Migrations.**

The Kaska form a portion of the group of tribes often referred to by the Hudson Bay Company's people as the Nahanie or Nahaunie, and so classed collectively by Dall in the absence of more definite information.*

For the northern district, drained by the Pelly, Stewart and other rivers, I am unfortunately unable to give much detailed information respecting the Indians, a circumstance due to the fact that we scarcely met any of these Indians, nor did we proceed far enough down the main river to meet the traders, from whom something might doubtless have been obtained. **Indians of northern district.**

The name of the Indian tribe inhabiting the Upper Pelly valley was given to me by the Indians at the mouth of the Dease as Ta-koos-oo-ti-na, by Indians met by us near the site of Fort Selkirk as Na-ai'. The territory of this tribe includes also the basin of the Macmillan and that of the Stewart as far down as the mouth of the Beaver, or "First North Fork," a very extensive region. I believe, however, that the names above noted either refer to local sub-divisions of the tribe, or are terms applied to them by neighbouring tribes and not recognized by themselves. Dall in his article already cited (following Ross) gives Abbăto-tenā' as the name of a tribe inhabiting the Upper Pelly and Macmillan, while Petitot places the name Esbá-ta-otinnè in the same **Indians of Upper Pelly.**

* *Op. Cit.*

region. Campbell again states that the Indians met by him on the Pelly were "Knife Indians," and I think there can be very little doubt that the true name of this tribe is Es-pā-to-ti-na, formed by the combination of the word Es-pā-zah (meaning knife in the neighbouring Kaska language) and ti-na. This is again evidently the same with the name rendered to me as Spo-to-ti-na by a trader in Cassiar and said by him, to be a Kaska name for the tribe to the north of their country.

From the Indians above mentioned as having been met with at the site of Fort Selkirk, who were travelling with miners, the following information was obtained:—

Tribes below Fort Selkirk.

A tribe or band named Klo-a-tsul-tshik′ (-otin?) range from Rink Rapid and its vicinity on the Lewes to the head of the east branch of White River, where they go at the salmon-fishing season. These people probably also range down the river as far as the mouth of the Lewes, or further. They are the Gens des Bois or Wood Indians of the fur-traders. It will be observed that their name does not terminate in the usual way, but of this no explanation could be obtained.*

The To-tshik-o-tin are said to live about the mouth of Stewart River, and to extend up the Stewart as far as the Beaver River, meeting there the Es-pā-to-ti-na to whom they are or were hostile. They are no doubt the Tutchone-kutchin of Dall's map.

Near the mouth of Forty-mile Creek are the Tsit-o-klin-otin and a short distance below this point on the river, so I was informed, is a tribe named Ka-tshik-o-tin. These were said to be followed by the Ai-yan′, below which come the O-til′-tin, the last tribe occupying the vicinity of the mouth of the Porcupine and extending some way up that river.

It was further stated that the people of the above mentioned tribes, with others, making seven in all, were collectively classed as Ai-yan′. This agrees sufficiently closely with the name Ai-ya′-na, given to me as a general name of Indians beyond those of the Pelly River by those found at the mouth of the Dease.

Number.

According to Schwatka the entire number of Indians along the main river from the mouth of the Lewes to the Porcupine is about 250. I can make nothing, however, of the local names given by him, with respect to which indeed he appears to have been himself in doubt.

The Indians inhabiting the whole basin of Peel River, were said, by my informants at Fort Selkirk, to be named Sa-to-tin. A tribe named

* Mr. Campbell informs me that in his time while a very few families of the "Knife Indians" inhabited the region of the Upper Pelly, the Indians were very numerous and divided into bands, under chiefs, along the river from Fort Selkirk to Fort Yukon. The "Wood Indians" numbered several hundreds. Below them on the river were the "Ayonais" as well as other tribes, of which Mr. Campbell was unable to learn the names.

San-to-tin' was further said to occupy the territory about a lake on White River and westward to extend down the Tanana River to a point nearly opposite the head of Forty-mile Creek. Below this people, on the Tanana come the Sa-tshi-o-tin' or "Bear Indians," Lieut. Allan* gives the names of tribes or bands along the Tanana, from its head down (though on doubtful authority) as Nutzotin, Mantototin, Tolwatin, Clatchotin, Hautlatin, the second and fourth of which seem to represent the names given to me. Tanana River Indians.

From the above information, such as it is, I think it probable that the Ai-ya'-na or Ai-yan people may be said to consist of the following tribes: Klo-a-tsul-tshik, To-tshik-o-tin, Tsit-o-klin-o-tin, Ka-tshik-o-tin, O-til'-tin, San-to-tin, and Sa-tshi-o-tin'. The name Ai-yan may be that of a premier tribe or of a meeting place common to the various tribes. The Ai-ya'-na would thus extend from the lower part of the Lewes to the mouth of the Porcupine, and include the basin of White River, together with the greater part or all of that of the Tanana. Conclusions.

The term Kutchin as a general suffix to the names of tribes, replacing *tinné*, *tina* or *otin* has, I believe, been carried much too far westward in this region on ethnological maps, being properly referable only to certain tribes situated to the north of the Ai-ya'-na and Es-pā-to-ti-na and lying between these and the Eskimo. Docking off this gratuitous termination from the names Han-kutchin and Tenăn'-kutchin applied as tribal names by Dall on the main river above the mouth of the Porcupine and along the Tanana River respectively; we may, with some probability, consider Han and Tenan as versions of Ai-yan. Differences such as this and others previously referred to in the rendering of Indian words—which are never clearly pronounced by the people themselves—are, as I think any one who has had some experience in endeavouring to reduce them to writing will admit, very easily explained. "Kutchin."

A grave was seen on the Upper Pelly, near the mouth of the Macmillan and others near the site of Fort Selkirk. There were the usual coffin-boxes, surrounded by pickets, and near them tall poles were set up, bearing streamers of cloth. Graves.

The Tagish Indians, occupy the greater part of the valley of the Lewes above the mouth of the Tes-lin-too, as well as the last-named river as far as to its efflux from Tes-lin Lake, the lake itself being in the Taku country. To the Tagish belong the group of lakes of which Tagish-ai or Tagish Lake is the principal. They may be said to be separated from the coast tribes by the water-shed ridge of the Coast Mountains on Chilkoot Pass, though the line of division is not apparently well drawn, and they likewise probably reach the head- Tagish Indians.

* Report of an Expedition to the Copper, Tanana and Koyukuk Rivers, etc., 1887.

waters of the Tahk-heena branch of the Lewes. The name of this stream evidently means Tagish River, and though I follow the usual orthography, this is incorrect. The precise line of demarcation between this tribe and the Taku, in the valley which connects A-tlin Lake with the Taku River, is not known. One of the Tagish people informed me that they claim also the head-waters of the Big Salmon River, and Lieut. Schwatka (who calls these people Tahk-heesh) in his report mentions having found some of them temporarily in occupation of a spot not far above the mouth of the Lewes. I believe, however, that this party may have been merely on a trading expedition and feel doubtful also of their extension to the Salmon, unless temporarily on some such errand. Their principal place is upon the short reach of river connecting Tagish Lake with Lake Marsh, where two rough wooden houses, somewhat resembling those of the Coast Indians, are situated. Here the greater part of the tribe congregates during the winter.

Territory.

Position and relations.

So far as I was able to judge, the Tagish in their mode of life and habits are identical with the Tinné Indians. They are classed with those as "Stick Indians," by the coast tribes, and have been assumed to be Tinné, but their language very clearly shows that they are in reality a Thlinkit people. Most of their words are either identical or very nearly so with those of the Thlinkit, while a few appear to resemble those of the Tinné. Till of late, they have been effectually dominated by the Chilkats and Chilkoots of Lynn Canal and have thus been kept poor both in goods and in spirit. From time immemorial they have been in the position of intermediaries in trade between the Coast and the Tinné Indians, without being sufficiently strong to levy a toll. On the question as to whether the blending of characteristics which they appear to show physically, as well as in other respects, has resulted only from intermingling of the two peoples, or may be regarded as preserving evidence of the actual derivation of the Thlinket from the Tinné, or its converse, I can offer no definite opinion. The question is, however, a very interesting one for further investigation, and may eventually throw light on the connection between these peoples, first, I believe, pointed out by my friend, the late Dr. W. F. Tolmie.*

Number.

The Tagish tribe is a very small one, and includes about fifteen families only, all told,—representing possibly seventy or eighty individuals. Their snow-shoes, together with their travelling and hunting equipment generally and their mode of camping, are identical with those of the Tinné, so far as I was able to observe.

* Comparative Vocabularies of the Indian Tribes of British Columbia.

At the lower end of Lake Marsh we found several graves which, no doubt, belonged to the Tagish. One was a small tent-shaped erection covered with calico, another a box wrapped in spruce bark and piled round with neatly cut pieces of wood and logs, held in place by pickets. A third, a similar box, on which billets of wood and finally rough branches and rubbish had been piled. The boxes were too small to contain the corpses of adults, even if placed in the constrained posture usual to Indians, and as the ground beneath and around each of the deposits was thoroughly burnt, it appeared quite possible that the bodies had been cremated and the ashes only coffined. Graves.

Respecting the Chilkat and the Chilkoot tribes of Lynn Canal, I can add little or nothing to what is already known. Lieut. Schwatka, in his report already referred to, speaks of these people as constituting divisions of a single tribe under the general name of Chilkat. They are certainly very closely allied, though in times past they have not always been at amity. Schwatka further states that "the Chilkats, proper, have three permanent villages, which are situated in the immediate neighbourhood of Pyramid Harbour, and at no great distance from each other. The Chilkoots, the other division of the tribe, have one village, situated permanently in the Chilkoot Inlet." These people are of course, in all respects, typical Thlinkit. They number, in all, according to Lieut. Symons, U.S.N., 981. Schwatka says they call the Tagish, in some connection, Si-him-e-na. Chilkat and Chilkoot Indians.

Mr. J. C. P. De Krafft* says that he was informed of the Chilkat, Chilkoot and neighbouring interior tribes, that they are all of the general classification Thlinkit, and name the whole region inhabited by them Kunana, the inhabitants Kunaäni. That one group of tribes named Alitch (being their name for people) consists of six small tribes viz.: Tagosh (living nearest the coast), Kluhtane, Netlatsin, Tahtlin, Klukha, and Tahho. Of the above names, most are recognisable as those of places in the Tagish country, and they may refer to the hunting-grounds of various families, but there is evidently some confusion respecting the names, which are quoted here chiefly with the object of suggesting further enquiry.

The subjoined table, giving a census of the Indian population of the Mackenzie River District, and including the Yukon region so far as known to the Hudson Bay Company in 1858, is of interest, as showing the tribal sub-divisions as recognized by the Company, and as throwing some light on the questions discussed above. The table is due to the late Chief Factor, James Anderson, and has been communicated to me through the kindness of his son. Hudson Bay Company's census.

* U. S. Senate Doc. 1 Session, 47th Congress, vol. iv, p. 100.

	Married.		Adults.		Children.		Total.		Total Males and Females.	
	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.		
Fort Simpson and Big Island.										
Slaves, Dog Ribs and Hares.	124	129	96	20	159	130	379	279	658	
Nahanies	13	14	35	....	12	13	60	27	87	—745
Fort Rae.										
Dog Ribs and a few Slaves and Yellow Knives.....	123	131	91	25	145	142	359	298	657	—657
Peel R. and La Pierre's House..										
Loucheux (Koochin). ...... A few Esquimaux occasional visitors.	81	92	21	7	83	53	185	152	337	—337
Yukon.										
Loucheux of six tribes...... These are all that resort to the fort.	135	156	121	75	218	137	474	368	842	—842
Fort Liard.										
Slaves........................	45	47	38	14	84	53	167	114	281	
Sicannies or Thicannies	12	16	7	....	16	27	35	43	78	
Nahanies.	9	9	2	....	11	7	22	16	38	—397
Fort Resolution.										
Chipewyans and Yellow Knives, with a few Dog Ribs and Slaves	98	149	....	....	119	103	217	252	469	—469
Fort Good Hope.										
Hare Indians..............	76	78	68	23	80	39	224	140	364	
Loucheux and Batard Loucheux	23	22	18	3	17	12	58	37	95	
Nahanies.	1	1	3	3	....	....	4	4	8	—467
Fort Norman.										
Slaves	19	19	10	2	20	14	49	35	84	
Hares	23	25	17	....	27	11	67	36	103	
Dog Ribs	22	24	21	9	28	29	71	62	133	
Nahanies	8	9	....	....	18	8	26	17	43	—363

	Married.		Adults.		Children.		Total.		Total Males and Females.	
	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.		
Fort Halkett.										
Sicannies or Thicannies.....	17	19	7	5	14	11	38	35	73	
Mauvais Monde, Batard Nahannies and Mountain Indians. All tribes of Nahannies	63	63	19	9	57	48	139	120	259	—332
										4609
Recapitulation.										
Slaves, Dog Ribs, Chipewyans and Yellow Knives, who are all of the same race, and speak — with slight variations — the same dialect of the Chipewyan language........	530	602	341	93	662	521	1533	1216	2749	
Nahanies or Mountain Indians, who speak a very corrupt dialect of the Chipewyan	94	96	59	12	98	76	251	184	435	
Sicannies or Thicannies, who also speak a dialect of the Chipewyan language	29	35	14	5	30	38	73	78	151	
Loucheux or Koochin and Batard Loucheux (half Hare, half Loucheux). Only some words of this language are understood by the Slaves	239	270	160	85	318	202	717	557	1274	
	892	1003	574	195	1108	837	2574	2035	4609	

SHORT VOCABULARIES OF THE TAHL-TAN, TI-TSHO-TI-NA, AND TA-GISH OBTAINED IN 1887.

The alphabet employed is identical with that of the "Comparative Vocabularies of the Indian Tribes of British Columbia," and is as follows:—

Vowels.

a	as in	English	*fat.*
ā	"	"	*father.*
e	"	"	*met.*
ē	"	"	*they.*
i	"	"	*pin.*
ī	"	"	*marine.*
o	"	"	*pot.*
ō	"	"	*go, show.*
u	"	"	*nut, but.*
y	"	"	*year.*
ai	"	"	*aisle.*
ei	"	"	*vein.*
oo	"	"	*pool, fool.*
eu	"	French	*peu* (seldom used).
ow	"	English	*now.*

The distinction of long and short vowels (following Gibbs) is noted as far as possible, by the division into syllables,—the consonant that follows a vowel being joined immediately to one intended to be pronounced short, while a long vowel is left open, being followed by a hyphen. When this is insufficient, or a nicer distinction is desirable, the usual long and short marks are supplied.

Explosive or klicking sounds are represented by the letters *k*, *t*, etc., in combination with an apostrophe, thus—*'k 't*.

An acute accent (′) at the end of a syllable indicates its accentuated character, when this is very distinct. In some cases certain syllables are run very hurriedly over and almost whispered, and though really forming a part of the word, might easily be omitted by a careless listener. Where this has been noted it is indicated by the use of smaller type. Strongly guttural syllables are printed in small capitals, thus,—*law*-KH. A nasal sound is denoted by a small letter above the line, thus—^{n}.

ENGLISH.	TAHL-TAN.	TI-TSHO-TĪ-NA.	TA-GISH.
Man	den′-e	skel-ē′-nă	tah-kā′-ne
Woman	e-ga-tēn′	is-tshī-yong	ug uh-tē′-na
Boy	etō-nē′	is-tshī′-ma	too-nī′-na
Girl	’tē′-da	is-too′-ā	ti-tshoo-tlug′-a-tē-na (*little woman*)
Infant	——	——	is-too′-ā
My father	e-te′-uh	a-ta′-a	e-tāh′
My mother	e-tlī	en-ā′	ah-mā′
My husband	es-kuh-lē′-na	sine-ske-lē- nă	uh-hoh′
My wife	es-tsi-yā′-na	sine-is-tshī-yong	us-sa-wut-tē
My son	es-tshī-me	sine-is-tshī′-ma	uh-hī-yit′-e
My daughter	es-too′-eh	sine-is-too′-ā	——
My elder brother	es-tī-uh	kut-ē′-uh	——
My younger brother	es-tshīt′-le	ē-tshī′ala	——
My elder sister	e-tā′-ta	a-tad-ē	——
My younger sister	es-tē′-juh	a-tad′-zuh	——
An Indian	dī-den′-e	den′-uh	tshut-lēk′
Head	es-’tsī	es-sē′	ka-suh
Hair	es-tsī-gā′	es-tsē-ga′	ka-sha-hā-oo
Face	es-snē	es-enē′	ka-guh′
Forehead	es-tsē′-ga	es-tsī′-ge	ka-kok′
Ear	es-thēs′-botl	sus-pā′-luh	ka-kook′
Eye	es-tā′	es-tā′	ka-wok
Nose	es-tshi′	es-tsī	ka-tlooh
Mouth	es-sāt′-a	es-zā-de	’kōh
Tongue	es-sā′	es-zā-de	ka-tloot′
Teeth	es-gooh′	es-ĕyuh′	ka-ōh′
Beard	es-stane′-GUH	es-ton-o-kh′	ka-kuh-tad-zai′
Neck	es-kōs′	es-’kōs	ka-hloo-tih′
Arm	es-sī-tluh	es-kā′-nuh	ka-tshīn
Hand	es-sluh′	es-sitā′	ka-tshīn
Fingers	es-sluh′ *or* slus-sē-guh	es-sitā′	ka-tlē-uk
Thumb	slus-tshō′	slas-tshō′	ka-koosh′
Little finger	slus-tshed′-le	——	——
Nails	is-lā-gun′-a	sla-kun-ā′	ka-hakwh
Body	es-hīa′	es-zī′	ka-kē-sin′
Chest	es-tshān	es-tzong	ka-hāt-ka′
Belly	es-bēt	es-pēt	ka-yoo-kuh′
Female breasts	ma-tō′-ja	es-tō′-ja	too-tlā
Leg	es-tsēn-a	es-tsut′-za	kā-kud′-ze
Foot	es-kuh′	es-’kiā′	ka-kōs
Toes	es-kus-tshō′ (*probably great toe*)	es-kuh-gau′-da′	ka-tlē-uk
Bone	es-tseⁿ′	es-tsun′-uh	tsāk

English.	Tahl-tan.	Ti-tsho-tī-na.	Ta-gish.
Heart	es-tshēa′	es-tzi-ā	ka-teh′
Blood	e-ted-luh	e-til-uh′	sheh
Village	kē-yē′	kon′-a	ai-ē-i-tī (?)
Chief	tin-ti′-na	tin-a-tē′-yuh	an-kow′
Warrior	e-ted′-etsha	——	——
Friend	es-tsīn-ē	sā-za	yu-keh′
House	kī-mah′	es-kon′-a	hīt
Brush wigwam	tso-la-hīt′	es-kon′-a	hīt
Kettle	’kōtl	sioo-sā′-a	kī-sha′
Bow	des-ān	sī-te-uh′	tshoo-net′
Arrow	’k-ah	es-kā-ah	kā-kutl
Axe	tsī-tl	tsēntl	shin-a-whā
Knife	pēsh	es-pā-zuh	klī-ta
Canoe	ma-lā′-te	sa-la-ah′	yakw
Moccasins	e-tshil-e-kēh′ (*skin shoes*)	es-kuh′	tītl
Pipe	t′	es-tzil-e-kē′-duh	tsik-ta-kēt′
Tobacco	tsē-a-KH	tzid-a-too′-de	tsē-uk
Sky	ya-za	kōs	tik-kī′
Sun	tshā	sā	ka-kun′
Moon	——	sā	itl-tīs′
Star	SUHM	sun	kwat-a-hin-a-ha
Day	zeu-ēs	do-te-dzuh	ha
Daylight	yē-kā′	——	——
Night	ih-klē-guh	kla-klē-ge	tāt
Morning	tshut-tshaw-tlunē′	e-klā-dzi	tsoo-tāt′
Evening	hīh-guh′	tlah-kā-ha′	hā′-nā
Spring	tā-nē′	ta-tuna-kā-ga	ya-kunē-tshatl′
Summer	klī-we-guh′	ī-pah	kus-sī-at′
Autumn	tā-tla′	——	yes’k
Winter	ih-ha-yēh	hat′-ya	——
Wind	it-tsī′	it-sī	nook
Thunder	it-ti-i-tshī′	it-tī-ji	in-dī-jeh′
Lightning	kun-ta-tsēl	kun-tā-tzil′	soon-tsha′-na
Rain	tshā′	tshaⁿ	tsoo
Snow	zus	zus	kliēt
Fire	kŏn	kun	’kān
Water	tsoo	too	hīn
Ice	tenⁿ	tun	’t-īk
Earth, land	nēn	nin	hoo-tī-tluk
Sea	ē-ētlă	ē-ētla	ē-’tl
River	too-dēsă	ta-kā′-koo-tsho (*when large*) too-za-za (*when small*)	hīn

ENGLISH.	TAHL-TAN.	TI-TSHO-TĪ-NA.	TA-GISH.
Lake	mēn	mēn	āh
Valley	tā-gōs′-ke	tsin-ī-tla	yīn-a-tlet′-ki
Prairie	’klo′-ga	a-tega	tshoo′-kun
Hill	tah	hi-za-za	shāh
Mountain	his-tsho	tsutl	——
Island	ta-ĕ-too-e	ta-dō-a	kā′-tuh
Stone, rock	tsē	tsa	tēh
Salt	ē-ētlă	——	ē-’tl
Iron	pes-te-zīn′	pē-zin	ki-ye′-tsuh
Forest	got-ĕ	——	shī-tī-hin-as (*many trees*)
Tree	tli-gē-gut′	tsoo	she-tlek′-as
Wood	tset-tsh-tsēlsh	tsutz	et-ka-whut′-ti
Leaf	e-tāne′	a-tōna	ke-ga-nĭ
Bark	ed-lā	se-tēd-za	a-hloo-nĭ
Grass	klōăh	klō-ye	tshoo′-kun
Pine	gā-za	——	kletl *or* kaon-sē
Cottonwood	——	——	tīe
Flesh, meat	e-tsēt′	a-tzun	tlī
Dog	klī	kli	kētl
Bear	shush	sus	hootz
Wolf	tshī-yō-ne	tshi-yō′-nuh	noos
Fox	nus-tsē′he	nis-tsā′	na-kat-sē
Deer	kīw-igana	——	——
Mountain-goat	——	——	tshen-oo
Mountain-sheep	——	——	tā-wēh′
Caribou	ō-tsī′	goo-dzi′	but-sīh′
Beaver	tshā	tsa	tsi-ge-di′
Rabbit, hare	guh	guh	kah
Fly	tsī-mēh	tso-tsa′	ka-kon-a-wit′-se
Mosquito	tsī	tsī-a	tā′-ka
Snake	——	——	ti-koo-too′-da
Bird	tsī-mēh	tīh	koktl
Egg	ē-ga-zuh′	ē-ga′-zuh	et-kot′-ē
Feathers	tshōsh	met-tshōsa	a-kwat′-le
Wings	mī-ī-tsēne	me-tzon-a	e-ki′-je
Goose	gān-jeh	gun-tsha	ta-wuk
Duck (*mallard*)	too′-deh	too′-dah	ka-whw
Fish	klew′-eh	hloo′-ga	Hat
Salmon	klew′-eh	gēs	tāh
Name	on-yēh	toon′-ya	——
White	ta-’kād′-le	ta-kud′-za	klē-tuh′-uh-tē
Black	ten-es-klā′-je	ten-as-kluz′-e	too′-teh
Red	te-tsī-je	a-tul-a′	ka-nuh′-e-te
Blue	te-tlesh′-te	det-līs-da	ta-tlin-suh
Yellow	tsīm′-tlet	ten-a-tsē-a	tsoo-yuh-uh-ta

English.	Tahl-tan.	Ti-tsho-tī-na.	Ta-gish.
Green	(*same as yellow*)	tsud-a-da-tsō′	(*same as yellow*)
Great, large	e-tsho	ta-etshō	a-tlin′
Small, little	ta-a-tsed′-le	ta-tzille′	ti-tshoo-tluh′
Strong	na-tī-yi	nun-tī	hlī-tsin′
Old	es-tshān	sa-ā	yoo-got
Young	es-kī-uh	tī-too	yīs
Good	e-tī′-uh	e-tē′-uh	ya-kā′
Bad	tshā′-ta	koos-tsa^-tsa	kon-ai-a-oo
Dead	a-juh′	a-jah	yoo′-na
Alive	te-tshī′	goo-te′	kwa-gi-tī′
Cold	hos-tlī′	goos-tli *or* el-oo-goo	ye-tīk
Warm, hot	hos-sītl	a-te-zulle′	yoo-tli-tik
I	shī-ni	nin′-e	hat
Thou	nīn-e	sin′-e	me-eh
He	a-yī-ge	ī-ye	——
We	ta-hun′-e	——	——
Ye	kla′-tse	——	——
This	tī-te	di-di	——
That	a-yī-ge	ī-ye′	——
All	sē-tse	ta-tē-da	ut-la-kut
Many, much	oo-tla^{n}	nus-tlo^{n}	shi-a-te-hen′
Who	ma-dai-e	——	——
Far	nī-sā-te	goo-din-e-sat′	na-hlī
Near	hah′-ne	ha-nā	kwun-a-sī
Here	tīs-tsik	——	——
To-day	too′-ga	di-doo-den-e	ye-ki′-yi
Yesterday	kit-sō′-kuh	ta-tsho^{n}	tet-kuh
To-morrow	tsha-tshā′	ta-tshon	tsoo-tāt′
Yes	ēh	ho^{n}	a-huh
No	tī-wuh	in-too-uh	klēk
One	tlī-geh′	e-tle′-ga	tshut-lēk
Two	tla-kēh	hlek-et-e-ta′	tēh
Three	tā-tē′	ta-di-da	natz
Four	klen-teh′	hlen′-ta	ta-koon′
Five	klo-dlāe′	klo-la′	kī-tshin′
Six	na-slikē′	nod-sli′-ga	kle-doo-shuh′
Seven	na-sla-kēh′	nod-i-slik-a	tuh-a-doo-shuh′
Eight	na-stāe′	nos-ta-di-da′	natz-ka-doo-shuh′
Nine	na-sten-tēh′	nos-ī-slen-e-ta	koo-shok′
Ten	tso-snā′-ne	tis-ēnō-go-anzi-tli-ga′	tshin-kat
Eleven	tso-snā′-ne-tes-liheh	tis-ēnō-go-anzi-la-kut-e-tla	tshin-kat-ka-tlah′
Twelve	o-dis-lā-kēh′	tleh-gad-ih-no′	tshin-kat-ka-tēh

English.	Tahl-tan.	Ti-tsho-tī-na.	Ta-gish.
Twenty	ten-tlă-dih-teh′	ta-tis-no	teh-tshin-kat
Thirty	ta-tsos-nan	tlen-tad-es-no	nats-tshin-kat
Forty	klon-ta-tsos-nan	klan-tad-es-no	ta-koon-tshin-kat
Fifty	tlo-tlāts-oos-nā-ne	hloo-lad-es-no	——
Sixty	na-stlik′-is-oos-nā-ne	no-sli-gi-tis-no	——
Seventy	na-slak-ets′-oos-nā-ne	no-sa-sla-kad-is-′no	——
Eighty	na-stā-e-tsoos-nā-ne	no-de-tad-es-no	——
Ninety	na-stlin-tēs-oos-nā-ne	no-slan-tad-es-no	——
One hundred	klo-la-ten-ān-e-ta	tis-no-kin-e-ta′	tshin-kat-ka
One thousand	——	——	——
To eat	etz-et-etz′	en-tsutz (?)	at-huh′
To drink	etz-oo-tān-en-e	too-in-to^{n}′	too-nuh′
To run	kīs-too-tshē′-ane	in-gulh′	klakw
To dance	en-dlē′	in-le′	kit-li-gatz′
To sing	en-tshīn	in-jīn	a-tshi′
To sleep	nes-tētl′	sin-te′	tah
To speak	hun-tēh	goo-din-tah′	yoo-kwa-tin′
To see	nat-sī	guan-es-ta′	hle-tin′
To love	na-is-tlook′	——	tloon-kut-la-tin (?
To kill	tsin-hia′	ze-hī	whā-tshuk
To sit	sīn-tuh′	sin-ta′	sī-tah′
To stand	nun-zit′	nun′-zut	git-a-han′
To go	un-tlēh′	had-in-tlelh	yuh-kōt
To come	a-nēh′	a-nī	ha-koo
To walk	yes-shā′-dle	had-in-tle′	yoo-tin-a-kooh′
To work	ho-ya-estluh′	kin′-hla	kloon-kut-tlai-yuh
To steal	en-a-ī	in-ī′	ha-ti-tih′
To lie	tse-es-tsīt′	toon-tsit′	skai-tli′-ilh
To give	me-ga-nī-āh′	ta	ī-ka′-wha-te
To laugh	na-es-tlook′	ted-in-tlooh′	a-tshook′
To cry	eh-tshih	en-tsai′	kāh

APPENDIX III.

LIST OF PLANTS COLLECTED BY DR. G. M. DAWSON IN THE YUKON DISTRICT AND ADJACENT NORTHERN PORTION OF BRITISH COLUMBIA IN 1887.

BY PROF. J. MACOUN, F.L.S.

NOTE.—References are also included to plants contained in a small collection made by Mr. W. Ogilvie, D.L.S., during the progress of his work on the Lewes River.

RANUNCULACEÆ.

1. *Anemone parviflora*, Mx.
   Cañon of Upper Liard River.
2. *Anemone deltoidea*, Hook.
   Dease Lake. Fl. June 8th. A rare and interesting species.
3. *Anemone Richardsoni*, Hook.
   Cassiar Trail twenty miles west of Dease Lake. A very remarkable species with yellow flowers.
4. *Anemone multifida*, DC.
   Frances River.
   Lake Bennett. (W. Ogilvie.)
5. *Anemone patens* L. var. *Nuttalliana*, Gray.
   Dease River, east of Cassiar Mountains; Upper Liard near Frances River; Upper Pelly River near its confluence with the Lewes.
6. *Ranunculus Flammula*, var. *reptans*, Meyer.
   "Pelly Banks;" Upper Pelly River.
7. *Ranunculus affinis*, var. *validus*, Gray.
   Cassiar Trail nine miles west of Dease Lake. Fl. June 5th.
8. *Ranunculus abortivus*, L.
   Cassiar Trail twenty miles west of Dease Lake. Fl. June 3rd.
9. *Aquilegia brevistyla*, Hook.
   Frances River.
10. *Delphinium scopulorum*, Gray.
    Hills west of Finlayson Lake.

11. *Caltha palustris*, L.
 Chilkoot Inlet. (W. Ogilvie.)
12. *Aconitum Napellus*, var. *delphinifolium*, Sevinge.
 Finlayson River. Very fine specimens.
13. *Actœa spicata*, var. *arguta*, Torrey.
 Telegraph Creek. Fl. May 28th.

NYMPHÆACEÆ.

14. *Nuphar polysepalum*, Engelm.
 Finlayson Lake.

FUMARIACEÆ.

15. *Corydalis glauca*, Pursh.
 "Pelly Banks," Upper Pelly River.
16. *Corydalis aurea*, var. *occidentalis*, Gray.
 Telegraph Creek. Fl. May 27th.

CRUCIFERÆ.

17. *Cardamine pratensis*, L.
 Frances River; Finlayson River.
18. *Cardamine hirsuta*, L.
 Hills west of Finlayson Lake.
19. *Arabis lyrata*, var. *occidentalis*, Watson.
 Cassiar Trail nine miles west of Dease Lake. Fl. June 5th.
20. *Arabis Holbœllii*, Hornem.
 Stikine River above the cañon. Fl. May 22nd.
 Telegraph Creek. Fl. May 27th.
21. *Barbarea vulgaris*, var. *arcuata*, Hook.
 Finlayson River.
22. *Sisymbrium incisum*, Engelm.
 Telegraph Creek; Stikine River. May 27th.
23. *Sisymbrium humile*, C. A. Meyer.
 Mouth of Lewes River. Aug. 15th.
24. *Draba nemorosa*, var. *hebecarpa*, Lindb.
 Tahl-tan River. Fl. May 31st.

VIOLACEÆ.

25. *Viola blanda*, Willd.
 Cassiar Trail 36 miles west of Dease Lake. Fl. June 2nd.

CARYOPHYLLACEÆ.

26. *Silene Douglasii*, Hook.
Dease River.

27. *Silene acaulis*, L.
Lake Lindeman. (W. Ogilvie.)

28. *Arenaria verna*, var. *hirta*, Wat.
Mouth of Lewes River.

29. *Arenaria congesta*, var. *subcongesta*, Wat.
Lewes River.

30. *Arenaria lateriflora*, L.
Telegraph Creek. Fl. May 27th.

31. *Arenaria physodes*, DC.
Pelly Banks; Mouth of Lewes River; Lake Lindeman.

32. *Stellaria longipes*, var. *minor*, Hook.
Telegraph Creek, Fl. May 27th; Tahl-tan River, Fl. June 1st; Lewes River.

33. *Cerastium alpinum*, var. *Behringianum*, Regel.
Hills west of Finlayson Lake.

34. *Cerastium trigynum*, Vill.
"Pelly Banks." Very rare.

LINACEÆ.

35. *Linum perenne*, L.
Upper Pelly River.

SAPINDACEÆ.

36. *Acer glabrum*, Torr.
Stikine River above the cañon. Fl. May 22nd. (The form with laciniate-lobed leaves.)

LEGUMINOSÆ.

37. *Lupinus Nootkatensis*, Donn.
Upper Liard River; Second North Fork of Stikine River. Fl. June 1st.

38. *Lupinus arcticus*, Watson.
Upper Liard River. A very interesting species.

39. *Astragalus alpinus*, L.
Forks of Liard and Dease rivers.

40. *Oxytropis campestris*, DC.
Upper Liard River.
Lewes River. (W. Ogilvie.)

41. *Oxytropis viscida*, Nutt.
Dease River.

42. *Oxytropis Lamberti*, Pursh (?)
Dease River.

43. *Hedysarum boreale*, Nutt.
Frances Lake.
Tagish Lake. (W. Ogilvie.)

44. *Hedysarum Mackenzii* Richards.
Telegraph Creek, Fl. May 27th; Upper Liard River.

ROSACEÆ.

45. *Prunus Virginiana*, L. (?)
Telegraph Creek. Fl. May 27th. A very remarkable form, and seems to be the one referred to on p. 167 of the Botany of California, as distinct from *P. demissa*, and yet not true *P. Virginiana*.

46. *Rubus arcticus*, L.
Francis River.

47. *Rubus arcticus*, var. *grandiflorus*, Ledeb.
Dease Lake. Fl. June 8th.

48. *Dryas octopetala*, var. *integrifolia*, Cham. & Schlecht.
Francis River, cool, shady bank, not seen in any other locality.

49. *Dryas Drummondii*, Hook.
Glenora, Stikine River. Fl. May 25th. (Common along river bars.)
Lewes River. (W. Ogilvie.)

50. *Geum macrophyllum*, Willd.
Hills north of Finlayson Lake.

51. *Fragaria Virginiana*, Duchesne.
Telegraph Creek. Fl. May 25th. Abundant locally over the whole region.

52. *Potentilla Norvegica*, L.
Mouth of Lewes River.

53. *Potentilla Hippiana*, var. *pulcherrima*, Wat.
Telegraph Creek. Fl. May 27th.

54. *Potentilla palustris*, L.
Lewes River.

55. *Potentilla fruticosa*, L.
Frances River. Very common throughout district.
Lake Bennett. (W. Ogilvie.)

56. *Poterium Sitchensis*, Wat.
Lake Lindeman; near the mouth of Lewes River.

57. *Rosa Sayi*, Schw.
Upper Liard River; "Pelly Banks"; Lewes River. August 26th (second flowering).

58. *Pirus sambucifolia*, Cham. & Schlecht.
Lake Bennett.
59. *Amelanchier alnifolia*, Nutt.
Telegraph Creek. Fl. May 24.
Dease River, east of Cassiar mountains.
Tagish Lake.

SAXIFRAGACEÆ.

60. *Saxifraga nivalis*, L.
Frances River.
61. *Saxifraga tricuspidata*, Retz.
Telegraph Creek, Fl. May 25th; Dease River, east of Cassiar Mountains.
Lake Bennett. (W. Ogilvie.)
62. *Tellima tenella*, Walp.
Telegraph Creek. Fl. May 27th.
63. *Chrysosplenium alternifolium*, L.
Dease River. Fl. June 7th.
64. *Parnassia palustris*, L.
Lewes River, near the cañon. Common generally along the rivers.
65. *Ribes setosum*, Lindl.
Glenora, Stikine River. Fl. May 25th.
66. *Ribes rubrum*, L.
Head of Dease Lake. Fl. June 7th.
Chilkoot Inlet. Fl. May 27th. (W. Ogilvie.)
67. *Ribes laxiflorum*, Pursh.
Dease Lake. Fl. June 7th.
68. *Ribes Hudsonianum*, Richards.
Glenora, Stikine River. Fl. May 25th.
Telegraph Creek. Fl. May 27th.

CRASSULACEÆ.

69. *Sedum stenopetalum*, Pursh.
Cañon of Lewes River.
Tagish Lake. (W. Ogilvie.)

HALORAGEÆ.

70. *Hippuris vulgaris*, L.
Lewes River.

ONAGRACEÆ.

71. *Epilobium coloratum*, Muhl.
 Lewes River.

72. *Epilobium augustifolium*, L.
 Common and generally distributed.
 Lake Bennett. (W. Ogilvie.)

73. *Epilobium latifolium*, L.
 Common along rivers generally.
 Lake Bennett. (W. Ogilvie.)

UMBELLIFERÆ.

74. *Selinum Dawsoni*, C. & R.
 Pelly River.
 Lake Labarge. (W. Ogilvie.)
 A new and very interesting species described in Coulter's Botanical Gazette, Vol. XIII. p. 144, June 1888.

75. *Archangelica Gmelini*, DC.
 Chilkoot Inlet. (W. Ogilvie.)

ARALIACEÆ.

76. *Fatsia horrida*, Benth. & Hook.
 Two miles from Kloochman Cañon, Stikine River, and in the valley on south side of Chilkoot Pass. Not seen in interior.

CORNACEÆ.

77. *Cornus Canadensis*, L.
 Common generally.

78. *Cornus stolonifera*, Mx.
 Telegraph Creek, and common generally.

CAPRIFOLIACEÆ.

79. *Viburnum pauciflorum*, Pylaie.
 Telegraph Creek, and generally abundant throughout the entire district.

80. *Linnæa borealis*, Gronov.
 Common generally.

RUBIACEÆ.

81. *Galium boreale*, L.
 Upper Pelly River; Tagish Lake; Lake Bennett.
 Lake Labarge. (W. Ogilvie.)

COMPOSITÆ.

82. *Solidago multiradiata*, Ait.
Tagish Lake. (W. Ogilvie.)
83. *Solidago Virgaurea*, var. *alpina*, Bigel.
Lewes River. (W. Ogilvie.)
84. *Aster occidentalis*, Gray.
Lewes River.
85. *Aster Sibiricus*, L.
"Pelly Banks;" Frances River; between Frances Lake and Pelly River.
Lewes River. (W. Ogilvie.)
86. *Erigeron acris*, L.
Lewes River.
87. *Erigeron acris*, var. *Dræbachensis*, Blytt.
"Pelly Banks"; Lake Lindeman; hills south of Pelly Banks.
88. *Erigeron compositus*, var. *discoideus*, Gray.
Telegraph Creek. Fl. May 25th.
89. *Erigeron cæspitosus*, Nutt.
Pelly River in two localities (above and below Macmillan River).
90. *Erigeron glabellus*, var. *pubescens*, Wat.
Near mouth of Lewes River.
91. *Antennaria plantaginifolia*, Hook.
Lewes River.
92. *Achillæa Millefolium*, L.
"Pelly Banks."
Tagish Lake. (W. Ogilvie.)
93. *Artemisia borealis*, var. *Wormskioldii*, Bess.
"Pelly Banks."
94. *Artemisia Canadensis*, Mx.
Pelly River.
95. *Artemisia vulgaris*, var. *Tilesii*, Ledeb.
Francis Lake; "Pelly Banks."
96. *Artemisia dracunculoides*, Pursh.
Pelly River.
97. *Artemisia frigida*, Willd.
Telegraph Creek, Fl. May 27th; Upper Pelly River; Dease River to east of Cassiar Mountains.
98. *Petasites sagittata*, Gray.
Second North Fork of Stikine River. Fl. June 1st.
99. *Arnica cordifolia*, Hook.
Telegraph Creek. Fl. May 28th.

100. *Arnica latifolia*, Bong.
Lake Bennett. (W. Ogilvie.)

101. *Senecio palustris*, Hook.
Hills south of "Pelly Banks."

102. *Senecio lugens*, Richards.
Upper Liard River; Frances River; hills west of Finlayson Lake.

103. *Senecio aureus*, var. *borealis*, T. & G.
Dease River; Finlayson River; Telegraph Creek. Fl. May 27th.

104. *Crepis elegans*, Hook.
Upper Pelly River above the cañon.

105. *Taraxicum officinale*, var. *glaucescens*, Koch.
Cañon of Upper Liard.

ERICACEÆ.

106. *Vaccinium uliginosum*, L.
Frances River; Lewes River; head of Bennett Lake.

107. *Vaccinium ovalifolium*, Smith.
Head of Bennett Lake.

108. *Vaccinium cæspitosum*, var. *cuneifolium*, Nutt.
Dease River; Cañon of Upper Liard.

109. *Arctostaphylos alpina*, Spreng.
Cassiar Trail twenty miles west of Dease Lake, Fl. June 3rd; also about height of land between Liard and Pelly, and on the Upper Pelly River.

110. *Arctostaphylos Uva-ursi*, Spreng.
Telegraph Creek. Fl. May 27th. Generally abundant.

111. *Loiseleuria procumbens*, Desv.
Chilcoot Pass. (W. Ogilvie.) Fl. June 10th.

112. *Ledum latifolium*, Ait.
First seen on Cassiar Trail about thirty miles from Dease Lake. Abundant on Upper Liard and Pelly rivers.
Tagish Lake. (W. Ogilvie.)

113. *Menziesia ferruginea*, Smith (?).
Lake Lindeman, and west slope of Chilkoot Pass.

PRIMULACEÆ.

114. *Primula Mistassinica*, Mx.
Francis River, in flower and quite common on river banks from which water had lately receded.

115. *Androsace septentrionalis*, L.
Telegraph Creek, Fl. May 27th; Glenora, Stikine River, Fl. May 24th.

GENTIANACEÆ.

116. *Gentiana Amarella*, var. *acuta*, Hook.
Finlayson River.
Lewes River. (W. Ogilvie.)
117. *Gentiana glauca*, Pall. (?)
On mountain near Finlayson River.

POLEMONIACEÆ.

118. *Polemonium cœruleum*, L.
Finlayson River; quite abundant about the height of land between Liard and Pelly rivers.
119. *Polemonium humile*, var. *pulchellum*, Gray.
Telegraph Creek. Fl. May 27th; Glenora, Stikine River, Fl. May 25th; very abundant and characteristic on south-east part of Cassiar Trail.

HYDROPHYLLACEÆ.

120. *Phacelia Franklinii*, Gray.
Cañon of Lewes River.

BORRAGINACEÆ.

121. *Echinospermum Redowskii*, var. *occidentale*, Wat.
Telegraph Creek, Fl. May 27th.
122. *Mertensia paniculata*, Don.
Cassiar Trail thirty miles south-west of Dease Lake. Fl. June 2nd. Common.
Lake Bennett. (W. Ogilvie.)

SCROPHULARIACEÆ.

123. *Castilleia pallida*, var. *septentrionalis*, Gray.
Lewes River.
124. *Collinsia parviflora*, Dougl.
Glenora, Fl. May 25th; Telegraph Creek.
125. *Euphrasia officinalis*, L.
Lewes River.
126. *Pedicularis hirsuta*, L.
Finlayson River.
127. *Veronica alpina*, L.
Hills west of Finlayson Lake; Finlayson River.

128. *Pentstemon confertus*, var. *cæruleo-purpureus*, Gray.
Cañon of Lewes River.
Tagish Lake. (W. Ogilvie.)

LENTIBULARIACEÆ.

129. *Pinguicula villosa*, L.
Frances River.

CHENOPODIACEÆ.

130. *Chenopodium capitatum*, Wat.
Telegraph Creek, Stikine River, Fl. May 27th; "Pelly Banks."
Lake Labarge. (W. Ogilvie.)

POLYGONACEÆ.

131. *Polygonum viviparum*, L.
Francis River.

ELÆAGNACEÆ.

132. *Elæagnus argentea*, Pursh.
Telegraph Creek, near confluence of Pelly and Lewes Rivers, and in several places on latter river.
133. *Shepherdia Canadensis*, Nutt.
In flower, abundant at Glenora and Telegraph Creek, May 23rd.

SANTALACEÆ.

134. *Comandra livida*, Richards.
Frances River.

BETULACEÆ.

135. *Betula papyrifera*, Ait.
Stikine River, May 22nd; Lewes River, near its mouth; Dease River. Occurs generally throughout the district, except along upper part of Pelly River.
136. *Betula glandulosa*, Mx.
Abundant everywhere in suitable localities.
137. *Alnus rubra*, Bong.
Frances Lake.
Chilkoot Inlet. May 27th. (W. Ogilvie.)

SALICACEÆ.

138. *Salix speciosa*, Hook. & Arn.
Upper Liard River.

139. *Salix cordata*, Muhl.
Upper Liard River. A singular form.

140. *Salix longifolia*, Muhl.
Upper Liard River.

141. *Salix conjuncta*, Bebb, n. sp.
Cassiar Trail twenty miles north-west of Dease Lake. June 3rd.

142. *Salix rostrata*, Rich.
Telegraph Creek. May 27th.

143. *Salix flavescens*, var. *Scouleriana*, Bebb.
Stikine River above Little Cañon. May 22nd.

144. *Salix reticulata*, L.
Finlayson River. Abundant in cold, mossy swamps about height of land between Liard and Pelly Rivers.

145. *Salix glauca*, L.
Near mouth of Lewes River.

146. *Populus trichocarpa*, T. & G.
Mouth of Lewes River, August 15th; "Pelly Banks"; Stikine River, above the cañon, May 22nd; Lake Francis; Dease River; Forks of Taiya River.

147. *Populus tremuloides*, Mx.
Generally abundant.

CONIFERÆ.

148. *Juniperus Virginiana*, L.
Telegraph Creek (arboreal); general elsewhere in a shrubby form.

149. *Pinus contorta*, Dougl.
Common along the coast.

150. *Pinus Murrayana*, Balf.
From the Little Cañon, on the Stikine, north-eastward to Devil's Portage, on the Lower Liard (McConnell); northward to Finlayson Lake; along Lewes River, from Lake Lindeman to mouth of, and up Pelly River to long. 133° 45′.

51. *Pinus Banksiana*, Lambert.
East of Devil's Portage, on Lower Liard (McConnell.)

152. *Picea Sitchensis*, Carr.
The most abundant forest-tree along the coast and on the seaward slopes of the Coast Ranges. Not found to the eastward of these mountains.

153. *Picea alba*, Link.

The most abundant forest tree over the entire region east of the Coast Ranges.

154. *Picea nigra*, Link.
More or less abundant over the entire region east of the Coast Ranges.

155. *Tsuga Pattoniana*, Engelm.
Forming groves in Taiya valley and on the mountains, Chilkoot Pass. Probably characteristic of the higher parts of the Coast Ranges throughout.

156. *Abies subalpina*, Engelm.
Bennett Lake, and generally on the mountains in the vicinity of the timber-line.

157. *Larix Americana*, Mx.
Extends westward twenty-two miles up Dease River, and northward along Upper Liard to lat. 61° 35′. Nowhere seen along the Pelly or Lewes.

ORCHIDACEÆ.

158. *Corallorhiza innata*, R. Br.
Upper Liard River.

159. *Calypso borealis*, Salisb.
Cassiar trail, thirty-six miles south-west of Dease Lake.

160. *Cypripedium montanum*, Dougl.
Lewes River. (W. Ogilvie.)

LILIACEÆ.

161. *Disporum Oregana*, Watson.
Glenora, May 27th.

162. *Allium Schœnoprasum*, L.
Frances River; mouth of Lewes River.
Lake Labarge. (W. Ogilvie.)

163. *Veratrum viride*, Ait.
Lake Lindeman; south slope of Chilkoot Pass.

164. *Zygadenus elegans*, Pursh.
Cañon of Lewes River. (W. Ogilvie.)

JUNCACEÆ.

165. *Juncus Lescurii*, Bolander.
Lewes River.

166. *Juncus castaneus*, Smith.
Lewes River.

Cyperaceæ.

167. *Eriophorum capitatum*, Host.
Upper Pelly River, above the cañon.
168. *Carex siccata*, Dew.
Upper Pelly River.
169. *Carex festiva*, Dew.
Lake Lindeman.
170. *Carex leporina*, L., var. *Americana*, Olney.
Stikine River, above the cañon, May 22nd; Telegraph Creek, May 27th.
171. *Carex atrata*, L.
Frances River.
172. *Carex aurea*, Nutt.
Upper Pelly River.
173. *Carex alpina*, Swartz.
Lewes River.
174. *Carex acuta*, L.
Lewes River.
175. *Carex ambusta*, Bailey.
Frances River; Lewes River; "Pelly Banks."
176. *Carex podocarpa*, R. Br.
Lewes River.

Gramineæ.

177. *Hierochloa alpina*, Roem. & Schultz.
Mountain near Finlayson River, alt. 4300 feet, lat. 61° 30′.
178. *Hierochloa borealis*, Roem. & Schultz.
Telegraph Creek; Upper Liard River; Lewes River.
179. *Phleum alpinum*, L.
Lake Lindeman.
180. *Agrostis scabra*. Willd.
Lake Lindeman
181. *Cinna pendula*, Trin., var. *mutica*, Vasey.
"Pelly Banks."
182. *Deyeuxia neglecta*, Kunth.
"Pelly Banks," and confluence of Lewes and Pelly rivers.
183. *Deyeuxia neglecta*, var. *brevifolia*, Vasey.
"Pelly Banks."
184. *Deyeuxia sylvatica*, Kunth.
Lewes River; "Pelly Banks."
Dease River.

185. *Deyeuxia Columbiana*, Macoun. n. sp.
Tagish Lake.
186. *Deschampsia cæspitosa*, Beauv.
Lewes River, and "Pelly Banks."
187. *Trisetum subspicatum*, Beauv.
Upper Liard River; "Pelly Banks;" Frances Lake; Finlayson Lake.
188. *Poa alpina*, Linn.
Lake Lindeman; "Pelly Banks."
189. *Poa cæsia*, Smith.
Lake Lindeman; Dease River; Frances River; "Pelly Banks."
190. *Poa cenisia*, All.
Hills west of Finlayson Lake.
191. *Festuca ovina*, L.
Lake Lindeman; "Pelly Banks."
192. *Festuca scabrella*, Torr.
Frances Lake, and Finlayson Lake.
193. *Agropyrum violaceum*, Lange.
Lake Lindeman; "Pelly Banks"; Lewes River.
194. *Hordeum jubatum*, L.
Lewes River.
195. *Elymus dasystachys*, Trin.
Dease River.

Equisetaecæ.

196. *Equisetum variegatum*, Schleicher.
Upper Liard River. June 2, 1887.

Filices.

197. *Aspidium fragrans*, Swartz.
On rocks, Frances River.
198. *Cystopteris fragilis*, Bernh.
Telegraph Creek.

Musci.

199. *Splachnum luteum*, L.
200. *Webera nutans*, Hedw.
Upper Liard River. June 27, 1887.
201. *Marchantia polymorpha*, L.
Upper Liard River. June 27, 1887.

APPENDIX IV.

ZOOLOGY.

List of Diurnal Lepidoptera by James Fletcher, F.R.S.C., F.L.S.

1. *List of Diurnal Lepidoptera collected in the Yukon District and adjacent Northern Portion of British Columbia.*

Specimens in this list, not otherwise noted, were collected by Dr. G. M. Dawson and assistant, J. McEvoy, in 1887.

Papilio Machaon, L., var. *Aliaska*, Scud. Frances River, July 1; three miles below summit of Chilkoot Pass (from Mr. McDougall). July 15, 1886.

Papilio Turnus, L., June 28, 1887; three miles below Little Cañon, Lower Liard (long. 128° 13′), McConnell; Devil's Portage, Lower Liard (long. 126° 10′), July 15, 1887, McConnell; Frances River (lat. 60° 29′), July 1.

Pieris Nelsoni, Edw, Telegraph Creek, Stikine River, May 27.

Pieris Napi, Esper. Arctic form, *Bryoniæ*, Ochs. Dease Lake, June 6.

Pieris Napi, Esper. Arctic form, *Bryoniæ*, Ochs., var. *Hulda*, Ed., West of Finlayson Lake (lat. 61° 45′, long, 130° 55′), July 28.

Pieris Napi (1); winter form *Venosa*, Scud. Dease Lake, June 17.

Pieris Napi (2); winter form *Oleracea-hyemalis*, Har. Frances River (lat. 60° 29′), July 1; Lewes River (lat. 61° 55′), August 27.

Anthocaris Ausonides, Bd. Cassiar Trail, ten miles west of Dease Lake, June 4; Telegraph Creek, Stikine River, May 29; Dease Lake, June 7.

Anthocaris Stella, Edw. Telegraph Creek, May 29.

Colias Christina, Edw. Upper Pelly River (lat. 62° 47′, long. 137° 20′) August 7; site of Fort Selkirk, August 17, Ogilvie.

Argynnis Chariclea, Schneid. Finlayson River (lat. 61° 40′, long. 130° 16′), July 22; Finlayson Lake, July 27; Upper Pelly River (lat. 61° 50′, long. 132°), August 3. Pelly or Yukon River, August 7, 1888. McConnell.

Argynnis Freya, Thunb. Cassiar Trail, ten miles west of Dease Lake, June 4; Dease Lake, June 5.

Phyciodes Tharos, Dru. Devil's Portage, Lower Liard (long. 126° 10′), July 15, McConnell.

Phyciodes Pratensis, Behr. Upper Liard River (lat. 60°), June 26.

Grapta Faunus, Edw. Fifty miles below Forty-mile Creek, Pelly or Yukon River, August 7, 1888, McConnell.

Grapta Progne, Cram. Lewes River (lat. 61° 55′), August 27.

Thecla Irus, Godt. Telegraph Creek, Stikine River, May 29; Cassiar Trail, twenty-two miles east of Telegraph Creek, June 1.

Chrysophanus Helloides, Bd. Upper Pelly River (lat. 62° 40′, long. 134° 30′) August 7.

Lycæna Sæpiolus, Bd. Devil's Portage, Lower Liard (long. 126° 10′), July 17, McConnell; Finlayson Lake, July 25.

Lycæna Couperii, Grote. Telegraph Creek, Stikine River, May 31; Cassiar Trail, thirty miles west of Dease Lake, June 2; Cassiar Trail, ten miles west of Dease Lake, June 4; Dease Lake, June 5; Devil's Portage, Liard River (long. 126° 10′), July 13, McConnell; Upper Liard River (lat. 60°), June 26; Frances River (lat. 60° 29′), July 1.

Lycæna Shasta, Edw. Upper Pelly River (lat. 61° 50′, long. 132°), August 3; Lewes River (lat. 62° 20′), August 21.

Lycæna Pseudargiolus, Bd. Lec.; winter form (1) *Lucia*, Kirby. Dease Lake, June 4; Dease Lake, June 8.

Lycæna Pseudargiolus, Bd. Lec.; winter form (2) *Marginata*, Edw. Cassiar Trail, twenty miles west of Dease Lake, June 3.

Lycæna Pseudargiolus, B.-L., winter form (3) *Violacea*, Edw. Cassiar Trail, ten miles west of Dease Lake, June 4.

Lycæna Amyntula Bd. Devil's Portage, Liard River (long. 126° 10′), July 17, McConnell.

Nisoniades Icelus, Lint. Telegraph Creek, Stikine River, May 27.

Nisoniades Persius, Scud. Dease Lake. June 4.

Nisoniades Juvenalis, Fab. Cassiar Trail, ten miles west of Dease Lake, June 4.

2. *List of Diurnal Lepidoptera collected by Mr. W. Ogilvie on Mackenzie River in* 1888.*

Papilio Machaon, L., var. *Aliaska*, Scud. Fort Macpherson (lat. 67° 20′), June 21.

Pieris Napi, Esper.; Arctic form *Bryoniæ*, Ochs., var. *Hulda*. Fort Macpherson (lat. 67° 20′), June 21.

* This and the following list do not come strictly within the limits of this report, but are included here to ensure publication.

Anthocaris Ausonides, Bd. Mackenzie River, July 8.
Colias Christina, Edw. Fort Good Hope (lat. 66° 15′), August 11.
Vanessa Antiopa, L. Ninety miles above Fort Good Hope (lat. 65° 20′), July 19; Fort Smith (lat. 60°), August 24.

3. *List of Diurnal Lepidoptera collected by Mr. Fredk. Bell, at the instance of Mr. R. G. McConnell, at Fort Simpson, Mackenzie River (lat.* 61° 52′), 1888.

Papilio Turnus, L. (Five specimens.) June 24 to July 8.
Pieris Napi, Esper. (2); winter form *Oleracea-hyemalis*, Har. (Thirteen specimens.) June 24 to July 8.
Colias Occidentalis, Scud. July 17.
Colias Christina, Edw. Male, July 17; female, July 25.
Grapta Progne, Cram. (Two specimens.) July 12.
Vanessa Milbertii. Godt. (Eleven specimens.) June 26 to July 20.
Limenitis Arthemis, Dru. (1); dimorphic form *Lamina*, Fab. (Three specimens.) July 23.
Erebia Discoidalis, Kirby. June 25.
Lycæna Pseudargiolus, Bd. Lec.; winter form (1) *Lucia*, Kirby. June 25.
Nisoniades Icelus, Lint. June 26.

FISHES, DETERMINED FROM PHOTOGRAPHS, BY DR. T. H. BEAN, UNITED STATES COMMISSIONER OF FISH AND FISHERIES.

Photographs were taken of some of the fishes met with, but no specimens were brought back. The photographs have been kindly examined by Dr. Bean, who enumerates the species represented as follows:—

Salvelinus namaycush, Walbaum.
Lake Trout. Frances River, July 2. Spent male, judging from great length of maxilla. "Much darker than the other lake trout, and with white instead of yellow flesh."

Salvelinus namaycush, Walbaum.
Lake trout. Frances Lake, July 14. "Ordinary lake trout of the region."

Esox lucius, Linné.
Pike. Frances Lake, July 12. Length, 3 feet 3 inches.

Coregonus Nelsoni, Bean.
Nelson's whitefish. Frances Lake, July 16; also Lake Lindeman, September 18.

Catostomus catostomus, Forster.
Northern sucker; small-scaled sucker. Frances Lake, July 16.

Thymallus signifer, Richardson.
Back's grayling. Finlayson River, July 19.

DESCRIPTION OF A NEW RED-BACKED MOUSE (EVOTOMYS DAWSONI) FROM THE HEAD-WATER OF LIARD RIVER, NORTH-WEST TERRITORIES.

BY DR. C. HART MERRIAM.

Of a few skins of birds and small mammals brought back, the only one of particular interest is that described below by Dr. J. Hart Merriam, *American Naturalist*, July, 1888. (The figure given with the original description, illustrating the dentition, is not here reproduced.)

"Dr. George M. Dawson, Assistant Director of the Geological and Natural History Survey of Canada, has kindly sent me for determination a red-backed mouse collected by him June 23, 1887, at Finlayson River, one of the northern sources of Liard River, in lat. 61° 30′ N., long. 129° 30′ W., altitude 3000 feet.

"So little is known of the small mammals of this remote and inaccessible region that it is not particularly surprising to find that the mouse collected by Dr. Dawson proves to be undescribed. In some respects it is intermediate between the circumpolar *Evotomys rutilus* and its more southern congener, *Evotomys gapperi.* But since it differs from both and no intermediate forms are known, it must be regarded as specifically distinct. Hereafter, should intergrades be discovered, it may be necessary to consider it a sub-species. It may be characterized as follows:—

EVOTOMYS DAWSONI, sp. nov.

Dawson's Red backed Mouse.

"Type in Museum of Geological and Natural History Survey of Canada, at Ottawa. From Finlayson River, a northern source of Liard River, N. W. T. (lat. 60° 30′ N., long. 129° 30′ W., altitude 3000 feet). Size, about equal to that of *Evotomys gapperi.* Measurements from mounted specimen (apparently well mounted and not at all stretched): Head and body, 75 mm.; tail vertebræ, 28 mm.—pencil, 8 mm. (total, 36 mm.); ears, from crown, 7 mm. Tail shorter and thicker than in *gapperi*, but longer and slimmer than in *rutilus*, in this respect (but no other) agreeing with a specimen collected at Fort Liard by Kennicott (No. 4562, U. S. National Museum). The hind foot is intermediate between that of *rutilus* and that of *gapperi*, being thicker than in *gapperi*, but not so thick as in *rutilus.* The ears conspicuously overtop the fur, fully equalling those of *gapperi.* The tail is bicolor, the yellowish of the under part occupying a little more than half of the circumference. It is well haired, and the terminal pencil is nearly black above (and 8 mm. long). The red dorsal stripe begins just behind the

eye and extends to the root of the tail. In color it is bright chestnut—not far from ferruginous; the sides are tawny gray, and the belly is strongly washed with ochraceous buff. The admixture of black-tipped hairs is as great as in *gapperi*, and it is very much more conspicuous, owing to the lighter ground-color of the back and sides. The result is a sort of 'peppery' appearance not seen in any other representative of the genus. There is a tolerably well-defined whitish post-auricular spot—an exaggeration of the pale blotch sometimes seen behind the ear in *rutilus*. The whiskers are black and white; they reach back to the shoulders, instead of stopping at the occiput, as usual in the genus. A blackish stripe, bordered below with fulvous, runs from the base of the whiskers to the tip of the nose. The projecting margin of the ear is well covered with reddish hairs, brightest on the interior of the auricle.

"*Cranial and Dental Characters.*—Unfortunately the skull was badly smashed and part of it altogether wanting; hence no cranial characters can be made out. The teeth, however, remain, and are represented in the accompanying cut [not reproduced]. Their most marked peculiarity, compared with those of *gapperi*, consists in the openly-communicating loops. The upper molar series measures 4·5 mm. on the crowns, 4·8 mm. on the alveolæ. The lower molar series measures 4·4 mm. on the crowns, 4·6 mm. on the alveolæ.

"I take great pleasure in bestowing upon this handsome mouse the specific name *Dawsoni*, as a slight recognition of the indefatigable zeal of its discoverer, the distinguished explorer and geologist, Dr. Geo. M. Dawson, who has added so much to the fund of knowledge relating to North-western Canada."—*C. Hart Merriam.*

APPENDIX V.

NOTES ON THE

LITHOLOGICAL CHARACTER OF SOME OF THE ROCKS COLLECTED IN THE YUKON DISTRICT AND ADJACENT NORTHERN PORTION OF BRITISH COLUMBIA.

By Mr. F. D. Adams, M.A.Sc.

(Of the rocks described below, Nos. 16, 25, 2, 4, 7 and 10 were collected by Mr. R. G. McConnell, "No. C." by Mr. W. Ogilvie, and the remaining specimens by Dr. G. M. Dawson.)

Stikine River, No. 16. (Near mouth of Clearwater River. See p. 55 B.)

Diabase Porphyrite.—A rock consisting of a fine-grained groundmass, through which crystals of plagioclase, augite and iron-ore are porphyritically distributed. The plagioclase individuals are well twinned and have good crystalline forms. The augite occurs in eight-sided crystals, both prinacoids being well developed, and the iron ore, which is ilmenite, partly decomposed to leucoxene. The groundmass is crypto-crystalline and microcrystalline. A good deal of chlorite and other decomposition products occurs disseminated through the rock.

Marsh Lake, No. 86. (North end of lake, near outlet. See p. 164 B.)

Diabase Porphyrite.—Resembles No. 16, but the porphyritic crystals are, as a general rule, smaller. The groundmass also, although for the most part microcrystalline, is in some places isotropic, consisting of glass.

Stikine River, No. 25. (Telegraph Creek. See p. 57 B.)

Diabase Tuff.—A somewhat fine-grained clastic rock a good deal decomposed, made up of irregular-shaped grains of plagioclase, pyroxene

and titanic iron ore, with a very little pyrite and some fragments of a fine-grained porphyritic rock. The majority of the grains are plagioclase, showing polysynthetic twinning, a few untwinned felspar grains are also present, some of which may be orthoclase. The plagioclase is a good deal decomposed, many grains consisting almost entirely of a cryptocrystalline or microcrystalline aggregate of calcite, kaolin and other decomposition products. The pyroxene is clear and colorless, being as a general rule less decomposed than the feldspar. It is biaxial, and shows the usual pyroxene cleavages, with a high angle of extinction on the clinopinacoid, which in one case reached 41°. It is sometimes decomposed to chlorite, a considerable quantity of this mineral also occurring scattered through the rock. The fragments of titanic iron-ore are for the most part decomposed to leucoxene, showing the characteristic cross-hatched structure. The fragments of fine-grained porphyritic rock above mentioned have a fine-grained groundmass, in which are imbedded lath-shaped crystals of plagioclase and crystals of augite, and are apparently pieces of a decomposed diabase-porphyrite. Traversing the section are several bands or streaks, much finer in grain and showing cataclastic structure, and which were evidently lines of motion caused by crushing.

Dease Lake, No. 8. (About eight miles from head of lake, west shore. See p. 78 B.)

A very fine-grained yellowish-green rock, with schistose structure and somewhat talcose appearance. Under the microscope it is seen to consist of an exceedingly fine-grained groundmass, almost opaque, in which are a few strings and irregular-shaped segregations of calcite and a number of porphyritic crystals of pyroxene. Under a very high power, the groundmass is seen to be composed largely of little shreds of a micaceous mineral, probably sericite, which are approximately parallel in position and give to the rock an appearance resembling flow structure. With this is associated a smaller quantity of a colorless mineral polarizing in dull bluish tints and with somewhat undulatory extinction, which resembles felspar, but does not show any lines of twinning. The pyroxene crystals are colorless. Cross sections are eight-sided, showing the development of both prism and pinacoids, with cleavages parallel to both and extinction parallel to the latter. It is biaxial, and longitudinal sections show a single set of cleavages, sometimes intersected by tranverse cracks. The extinction direction makes an angle with this cleavage, which in one case was as high as 34°. The crystals are short and stout, and are occasionally twinned, they generally have good crystalline forms, but are sometimes broken.

A few grains of pyrite and a little chlorite are also present in the rock. As would be expected from the appearance of the hand specimen, the section shows that the rock has been subjected to a good deal of motion, two varieties of the rock differing somewhat in appearance, being irregularly mixed with one another. It is probably *some highly altered basic igneous rock;* the presence of the pyroxene crystals, retaining, as a general rule, their crystalline form, is however, somewhat remarkable.

Tagish Lake, No. 93. (Windy Arm. See p. 171 B.)

Felsite.—An exceedingly fine-grained rock, much crushed and altered. Small irregular-shaped segregations of calcite are scattered through the rock, and here and there little fragments of plagioclase can be seen. It is impossible by means of a section alone to determine its original character. Before the blowpipe it fuses easily to a black magnetic globule, and may provisionally be termed a *felsite.*

Cassiar Trail, No. 4. (Tooya River, at trail-crossing. See p. 70 B.)

Tuff?—An exceedingly fine-grained, red, somewhat schistose rock, holding numerous irregular-shaped cavities, filled with a light green chloritic mineral, mixed with calcite. The section is rendered nearly opaque by a dense impregnation with iron-oxide. It is also traversed by thin veins of calcite. Before the blowpipe the rock fuses to a black magnetic bead. It is probably an altered tuff.

GRANITIC ROCKS FROM THE COAST RANGES.

Wrangell, No. 2. (Wrangell Island. See p. 54 B.)

Biotite Granite.—A rather fine-grained gray granite, with very indistinct foliation. It is composed of quartz, orthoclase, plagioclase, biotite and epidote, with a very small amount of apatite and of an isotropic mineral, light brown in color, with high index of refraction, but without good crystalline form, and which is probably garnet. Almost every grain of quartz exhibits, between crossed nichols, an uneven extinction, showing that the rock has been submitted to pressure. Both the orthoclase and plagioclase are generally fresh. The epidote, which is present in considerable amount, is colorless, strongly doubly refracting, and is almost always associated with the biotite. It occurs in curiously corroded, somewhat elongated, prismatic crystals, with perfect cleavage parallel to the longest axis, the plane of the optic

axes being at right angles to this cleavage. The mode of occurrence of this epidote is very similar to that found in the mica-diorite from Stony Point, on the Hudson River, and described by Dr. George Williams (*American Journal of Science*, June, 1888).

Stikine River, No. 4. (Near mouth of river. See p. 54 B.)

A Porphyritic Biotite Hornblende Granite, approaching a Quartz Diorite in composition.—A medium-grained grey rock, with numerous small white porphyritic crystals. It is composed of quartz, plagioclase, orthoclase, biotite and hornblende. The porphyritic crystals are felspar, which is almost invariably plagioclase. They possess a zonal structure, and contain numerous colorless inclusions heaped up toward the centres of the crystals. Some of them also contain inclusions of muscovite, which is probably a decomposition product. The quartz generally shows an uneven extinction, owing to pressure. The plagioclase preponderates largely over the orthoclase, but some untwinned grains have been referred to the latter species. The biotite and hornblende are intergrown with each other. Two or three grains showing granophyr structure are also seen in this section.

Stikine River, No. 7. (Moraine of Great Glacier. See p. 54 B.)

Biotite Hornblende Granite.—A rather coarse-grained grey granite, with very indistinct foliation. It is composed of quartz, orthoclase, plagioclase, biotite, hornblende, sphene and magnetite. The quartz shows a somewhat uneven extinction. Both feldspars often show zonal structure. The hornblende is about equal to the mica in amount, and only small quantities of sphene and magnetite are present. The latter is probably titaniferous.

Stikine River, No. 10. (Little Cañon. See p. 54 B.)

Biotite Granite.—A coarse-grained grey granite, poor in mica. The orthoclase, of which there is a very large amount, often shows an indistinct zonal structure. A small quantity of magnetite, or more probably ilmenite, with which a little sphene is associated, is also present. A crystal of zircon was observed in one of the mica grains. Although the rock has no foliation, it shows very distinct cataclastic structure, induced by great pressure. The constituent minerals are seen to have been much squeezed and twisted, the larger grains being often, around their edges, broken up into a very fine-grained mass. The mica also, which is in part decomposed to chlorite, has been in many places pulled apart into shreds.

GRANITIC ROCKS FROM THE INTERIOR RANGES.

Upper Pelly River, No. 61. (Near mouth of river. See p. 132 B.)

Muscovite Biotite Granite.—A medium-grained grey granite, with very indistinct foliation. It is composed of quartz, orthoclase, microcline, plagioclase, muscovite, biotite and epidote, with small amounts of garnet, sphene, pyrite and calcite. The plagioclase is present in relatively smaller amount than in the granites from the Coast Ranges. The muscovite is more plentiful than the biotite. The epidote occurs in colorless corroded crystals, and has the appearance of an original constituent of the rock. The garnet is reddish, and occurs in a few irregular-shaped isotropic grains, usually much cracked. The sphene occurs in the usual wedge-shaped crystals. The calcite is seen in the section in a few large grains. The grains of quartz and orthoclase are somewhat cracked and broken, but beyond this, no distinct evidence of pressure is exhibited by the section.

Upper Pelly River, No. 57. (Granite Cañon. See p. 130 B.)

Biotite Granite.—A rather coarse grained, much decomposed, massive grey granite. The feldspars are so decomposed that it is difficult to determine their character, but a considerable amount of plagioclase is present, and probably a still larger amount of orthoclase. The biotite is entirely decomposed to chlorite and epidote. A few small grains of hæmatite are present in the section. The quartz grains are much cracked, and show very uneven extinction, owing to the pressure to which the rock has been subjected.

Pelly or Yukon, "No. C." (Opposite Stewart River. See p. 34 B.)

Quartoze Biotite Gneiss.—A rather fine-grained red gneiss, showing very distinct foliation. It is composed of quartz, orthoclase, plagioclase, calcite, chlorite, ilmenite and a little pyrite. The plagioclase is present in rather small amount. The chlorite is a decomposition product, probably of biotite, and the calcite, of which there is a considerable quantity, is also a decomposition product. The ilmenite is partly altered to leucoxene. The cataclasic structure is distinctly seen in the section.

Upper Pelly River, No. 53. (Nine miles above Macmillan. See p. 129 B.)

Biotite Granite.—A rather coarse-grained, reddish-grey, massive rock, composed of quartz, orthoclase, plagioclase and chlorite, with a

little ilmenite and pyrite. Both feldspars are much decomposed, being in some places nearly opaque. The plagioclase, which is not so plentiful as the orthoclase, is generally better crystallized, and frequently occurs in crystals penetrating this mineral. The ilmenite is partly decomposed to leucoxene, and the chlorite is evidently a decomposition product of biotite. The section is traversed by a little very fine grained granitic vein, showing a banded structure parallel to its walls. The quartz has been much cracked, nearly every grain showing an uneven extinction.

APPENDIX VI.

METEOROLOGICAL OBSERVATIONS.

The Meteorological Observations here recorded are as follows:—

1. Observations made along the line of route, June 1 to September 19, 1887.
2. Observations at Telegraph Creek, Stikine River, by Mr. J. C. Callbreath, 1881–1886.
3. Observations at Laketon, Dease Lake, by Mr. J. Clearihue, 1878-1882.
4. Record of temperature at Laketon, Dease Lake, by Mr. Robert Reed, 1886–1887.

The observations included under Nos. 2, 3 and 4 are unfortunately very incomplete. They refer to the winter months only, and in general the minimum reading of the thermometer alone is recorded. The thermometers employed were, however, instruments of good class by well-known makers, and in view of the paucity of information bearing on the region, it has been considered useful to print them. I am indebted to Mr. Callbreath for the opportunity of extracting the observations made by him from his diaries, and to Mr. Reed for communicating the third and fourth series of observations. The observations forming the first part of this appendix were recorded by Mr. J. McEvoy during the progress of our journey.

G. M. D.

(1) METEOROLOGICAL OBSERVATIONS IN THE YUKON DISTRICT AND ADJACENT NORTHERN PART OF BRITISH COLUMBIA, JUNE 1 TO SEPTEMBER 19, 1887.

The barometer readings are those of a single pocket aneroid (Cary No. 859) checked at intervals by reference to the mercurial barometer and corrected according to a table of differences based on these comparison. Readings made on two additional aneroids and employed in the determination of elevations are not here included.

Temperature is stated in degrees Fahrenheit. Thermometers employed, Nos. 60,361 and 60,363, Kew Observatory.

The force of the wind is estimated according to Beaufort's scale. The proportion of the sky covered by clouds is estimated by a scale of 0 to 10, 0 being a cloudless sky, 10 a completely clouded sky. The character of the clouds is denoted by the usual letters or combination of letters refering to Howard's classification.

PLACE.	Date.	Hour.	Barometer corrected.	Ther. corrected.			Direction of wind.	Force of wind.	Amt. of cloud.	Kind o cloud	Temperature of water.	Weather at time.	Weather during last interval.
				Air.	Max.	Min.							
				°	°	°					°		
Tahl-tan Bridge, Cassiar Trail, 10 ft. above river	June 1	5.00 a.m.	29.86	36.5	...	30.5	W.	1	8	C & K.	.....	.....	Detached Clouds.
Wilson's	" 1	7.00 p.m.	......	59.			W.	1	2	K.	.....	Fair.	" " and blue sky.
"	" 2	5.00 a.m.	28.34	39.		30.5	Calm.		1	C.	.....	"	Passing clouds.
Cariboo Camp	" 2	7.00 p.m.	27.89	51.			N.W.	3	7	K.	.....	Showery.	Fair. Clear and passing showers.
" "	" 3	5.20 a.m.	27.96	42.	...	37.	Lt. var.	..	9	C K.	.....	Dull.	Showers. Detached clouds and overcast.
24-m. post	" 3	7.00 p.m.	27.97	54.5			N. E.	3	1	C.	.....	Fair.	Passing showers.
" "	" 4	6.45 a.m.	28.18	49.		31.	N. E.	4	0	.....	.....	.....	Clear.
Nine-mile Creek	" 4	7.00 p.m.	27.59	60.5			N. E.	3	0	.....	.....	Clear.	Clear. Very warm all day.
" "	" 5	6.40 a.m.	27.52	41.		28.	N. E.	2	0	.....	.....	"	Very light C. clouds.
Head of Dease Lake	" 5	7.00 p.m.	27.35	63.			S. E.	2	1	C.	.....	Hazy.	Clear. Very warm.
" " "	" 6	7.00 a.m.	27.41	48.5		45.5	Calm.	....	0	.....	.....	.....	Fair.
" "	" 6	7.00 p.m.	27.25	63.	76.		W.	3	...	.....	.....	Hazy.	" " Hot sun all day. Open water 3 m. on lake.
" "	" 7	7.15 a.m.	27.33	45.		35.	N. W.	1	...	.....	.....	.....	Clear. Strong N.W. wind.
" " "	" 7	7.10 p.m.	27.26	63.	74.		S.	1	...	.....	.....	Hazy.	" Light beeeze.
" " "	" 8	7.00 a.m.	27.27	...		32.	N.	1	1	C.	.....	"	" Calm.
Dease Lake, 5 m. down	" 8	7.00 p.m.	27.14	61.			N.	1	1	C & K.	.....	.....	" Light N. airs.
" " "	" 9	7.00 a.m.	27.26			29.5	N.	2	1	C.	.....	.....	Cloudy. " "
" " "	" 9	7.00 p.m.	27.19	57.	68.		N. N. W.	1	8	K.	.....	.....	Clouds. S. wind 3. Hot sun.
" " "	" 10	7.00 a.m.	27.28	49.		35.5	N.	3	10	S.	.....	Threatening.	Gloomy. Overcast.
" " "	" 10	7.00 p.m.	27.30	50.	63.		N. E.	2	9	C & S.	.....	Raining.	Rain. Wind S. & E. 5. Showery p.m.
" " "	" 11	7.00 a.m.	27.31	41.5		37.5	Lt. var.	..	10	S & C.	.....	Gloomy, ugly.	Overcast. Gloomy. Calm.

Dease Lake, 5 m. down	"	11	7.00 p.m.	27.29	55.5	67.5	...	W.	1	1	K.	.....	.....	Light showers. Light N.E. airs.
" " "	"	12	7.00 a.m.	27.83	44.	....	28.	Calm.	....	8	K & C.	.....	Hazy.	Light W. wind.
" " 10 m. down	"	12	7.00 p.m.	27.21	53.	....	..	W.	1	1	C & K.	.....	.....	C. clouds. Light W. wind.
" " "	"	13	7.00 a.m.	27.25	43.	..	32.	S.	2	1	C K.	.....	.....	Light S. Wind. Ice formed on pools.
" " "	"	13	7.00 p.m.	27.18	52.5	63.	....	S. W.	2	10	S.	.....	Gloomy.	Clouded over. p.m., strong S. wind for a while.
" " "	"	14	7.20 a.m.	27.18	41.5	....	38.5	Lt. var.	....	4	S.	....	"	
" " "	"	14	7.00 p.m.	27.12	46.5	52.	...	Calm.	...	10	S.	....	Clearing.	Raining all p.m.
" " "	"	15	7.10 a.m.	27.19	49	..	39.	S.	1	5	C K.	.....	Breaking.	Overcast. Raining.
" " "	"	15	7.00 p.m.	27.17	56.	59.5		S.	1	10	K S.	.....	Threatening.	Detached clouds. Lt. sprinkle from S.
" " "	"	16	7.00 a.m.	27.26	44.	....	40.7	S.	2	10	K S.	.....	"	Overcast. Gloomy. S. wind 4.
" " Laketon	"	16	7.00 p.m.	27.28	...	....	....	S.	3-4	5	K.	.....	Showery.	Light showers. " 2.
" " "	"	17	8.00 a.m.	27.23	..	....	....	S.	1	5	K.	...	.....	
" " "	"	17	7.00 p.m.	27.17	..	.	..	S.	1	7	K.	.....	Showery.	Hail and rain showers. p.m., N. & S. var. wind.
" " "	"	18	7.30 a.m.	27.12	.....	.....	..	Calm.	...	9	S.	.....	.....	Passing showers.
" " Porter's Landing	"	18	7.00 p.m.	27.03	49.	...	...	N.	1	8	C S.	.....	Showery.	Showery all day. Wind 3 var. N. & S.
" " " "	"	19	7.00 a.m.	27.22	45.	....	39.	S.	1	10	K S.	.....	Raining, foggy.	Heavy rain.
" River, 1st camp	"	19	7.00 p.m.	27.38	53.	..	...	S. W.	2	1	K.	.....	.....	Rainy morning, cleared up 9 a.m.
" " "	"	20	6.30 a.m.	27.44	43	....	36.5	S.	2	3	C light.	....	.....	Fair. C. clouds. Wind S.W. 2.
" " McDame Creek	"	20	7.00 p.m.	27.51	64.	....	...	S.	1	10	K S.	.....	Gloomy, ugly.	Overcast Dull. p.m., wind S. 2.
" " " "	"	21	6.30 a.m.	27.60	48.	....	41.5	Calm.	....	10	S.	.....	Dull, "	Heavy rain during night. Wind 3.
" " " "	"	21	7.00 p.m.	27.54	61.	.	...	"	...	10	K S.	46.	Showery.	Detached clouds W. air.
" " " "	"	22	6.30 a.m.	27.60	54.	. .	44.5	S.S.W.	1	1	K.	.....	.....	Wind 4. Cleared off.
" " " "	"	22	7.00 p.m.	27.69	56.	....	....	S. W.	3	8	K & C K.	47.	.....	Showers of rain and hail. Wind 2.
" " " "	"	23	6.20 a.m.	27.68	41.	...	....	S. W.	2	10	S & K S.	....	Gloomy.	Cold. Windy. River rose 15 in. during night.
Mouth of Dease River	"	23	7.00 p.m.	27.66	49.	..	...	S. W.	1	10	S.	45.5	Heavy Rain.	Cold heavy rain. River rising.
" " "	"	24	8.15 a.m.	27.70	43.	...	41.	W.	1	10	S.	.....	"	Heavy rain, River fell 1 ft.
" " "	"	24	7.00 p.m.	27.68	46.	....	..	W.	1	10	S.	.....	Raining.	Steady rain all day.
" " "	"	25	7.00 a.m.	27.79	45.	..	40.	W.	1	10	S & K S.	....	Gloomy.	Showers last night. Clouds a little broken. River fell.
Liard River, foot of cañon	"	25	7.00 p.m.	27.76	51.	..		W.	1	10	S & K S.	45.	"	Showery. Generally overcast.
" " " "	"	26	6.00 a.m.	27.81	43.	....	41.	N. W.	1	9	K S.	.....	.....	Light showers. River fell 3 in.
" " 6 m. above "	"	26	7.00 p.m.	27.67	58.	...	....	S.	1	5	K.	49	Fair.	K. & C. clouds. 2 to 8, sunshine.
" " " "	"	27	6.00 a.m.	27.69	50.	....	49.	W.	2	9	K S.	....	Gloomy.	Calm night. River fell 2½ in.
" "	"	27	7.00 p.m.	27.66	61.5	...	..	W.	2	1	C.	52.	Hazy.	C. & K. clouds.
" "	"	28	6.00 a.m.	27.79	54.	....	44.5	Calm.	.	1	C.	.....	.....	Calm night. River rose 2 in.
" "	"	28	7.00 p.m.	27.73	61.5	....		W.	2	5	K S.	52.5	.....	K. clouds. Showers. Warm day.
" "	"	29	6.00 a.m.	27.76	47.5	..	46.5	N.	1	9	S & K S.	.....	Rainy, gloomy.	Dull. Light showers this morning. River rose 1 in.
Frances River	"	29	7.15 p.m.	27.63	57.	....	..	Calm.	....	1	K.	50.5	.....	Warm day. K. clouds 3
" "	"	30	6.00 a.m.	27.63	45.	...	36.	"	..	2	C K.	.....	.....	Calm night.
" "	"	30	7.00 p.m.	27.65	55.	...	....	"	...	1	C & K.	48.5	.....	p.m. S. 10. Lt. rain. Cleared off 5 p.m.
" "	July	1	6.00 a.m.	27.58	48.	....	30.	"		9	C K.	.....	Gloomy.	Clear sunshine early this morning.
" " head of 1st cañon	"	1	7.00 p.m.	27.43	59.	...	...	"	...	4	K.	48.5	.....	Detached K. clouds.
" " " "	"	2	6.00 a.m.	27.38	49.	....	43.5	"	..	1	C.	.....	.....	Calm. K. 4.
" "	"	2	7.00 p.m.	27.25	55.5	....	...	S.	1	9	K & S.	49.	Gloomy.	Light passing showers. Wind S.
" "	"	3	6.00 a.m.	27.34	46	....	44.5	S.	1	1	C.	.....	.....	Several showers during night. Wind S
" "	"	3	7.00 p.m.	27.32	54.	....	....	W.	1	1	K.	47.	.....	K. 5. Light S. wind.

PLACE.	Date.	Hour.	Barometer corrected.	Ther. corrected. Air.	Max.	Min.	Direction of wind.	Force of wind.	Amt. of cloud.	Kind of cloud.	Temperature of Water.	Weather at time.	Weather during last interval.
				°	°	°							
Frances River	July 4	6.30 a.m.	27.29	38.		27.	Calm.		10	S.		Gloomy.	Clouded over during night.
" "	" 4	7.00 p.m.	27.16	52.			N.W.	1	5	K & S.		Showery.	Drizzling rain a.m.; p.m., showery.
" "	" 5	6.00 a.m.	27.30	44.5		37.	S.	1	10	S & K S.			Two showers during night.
" " 2nd cañon	" 5	7.00 p.m.	27 34	51.			N.W.	1	8	K.	46.5		Showery. Heavy K. clouds 6.
" " "	" 6	6.00 a.m.	27.39	49.		33.	N.	1	2	C & K.			Fairnight. K. 5.
" "	" 6	7 00 p.m	27.38	50.			Calm.		8	K.	46.		K. clouds 1-6.
" "	" 7	5.30 a.m	27.81	40.		36.	"		10	S.		Gloomy.	Overcast.
" " near foot of lake.	" 7	7.00 p.m.	27.81	42.5			S. W.	1	3	K.	45.		Showers. Hail in evening.
" " " "	" 8	6.00 a.m.	27.18	41.5		32.	S. E.	1	1	C.			K.& S. clouds. Ice ⅛ in. River fell 1 in.
" Lake	" 8	7.00 p.m.	27.11	51.			Calm.		8	C & K.	50.		Showery. Wind S. K. 1-8. Rather warm.
" "	" 9	6.30 a.m	27.22	47.		36.	"		9	K & S.		Gloomy.	Shower this morning.
" "	" 9	7.00 p.m.	27.26	52.			"		9	K & K S.	49.7		Showery. N. wind 4. K. 1-8.
" "	" 10	6 00 a.m.	27.33	47.		43.	S.	1	10	K & K S.		Gloomy.	Calm. Overcast. K. S.
" "	" 10	7.00 p.m.	27.32	49.			S.	1	10	K & S.		Raining.	Rain storms all day. 1st thunder of season.
" "	" 11	7.00 a.m.	27.42			34.5	W.	1	3	K.		Fair.	Showery.
" "	" 11	7.00 p.m.	27 42	45.	63.		S. W.	1	8	K & K S	46.	Showery.	Showers all day. Wind W. Warm sun
" "	" 12	6.20 a.m.	27.49	48.		29.	W.	1	6	K.		Fair.	Fair night. Clear.
" "	" 12	7 00 p.m.	27.34	51.	62.		S.	1	1	C.	47.5	"	Few showers. Wind S. 2. Lake fell 6 in. in 3 days.
" "	" 13	6.00 a.m.	27.24	41.		32.	N.	1	9	K & K S.		Raining.	Fair. K. 6. Clouded up this morn.
" "	" 13	7.00 p.m.	27.17	58.	66.		Calm.		9	K & K S.	51.		Showers. Lake fell 4 in.
" "	" 14	6.00 a.m.	27.20	46			"		10	K & S.		Gloomy.	Rain all night.
" "	" 14	7.00 p.m.	27.32	50.	58.		S.	1	8	C & S.	46.	Hazy.	Showers. Gloomy, Water fell 3 in.
" "	" 15	7.00 a.m.	27.33	41.		24.	N.	1	10	S.		Raining.	Rained latter part of night.
" "	" 15	7 00 p.m.	27.32	41.	58.		S.	1	9	C & S.	49.		Raining a.m.; p.m. cleared.
" "	" 16	7.00 a.m.	27.39	52.5		40.	Calm.		1	K & C.		Fair, clear.	Fair.
" "	" 16	7.00 p.m.	27.35	60.	65.		"		1	K.			Sprinkle. K. 1-4. Little thunder.
" "	" 17	6.00 a.m.	27.43	45.		29.	"		1	C.		Fair, clear.	Fair.
Finlayson River, 3 m. up	" 17	7.00 p.m.	...	55.5			E. N. E.	2	9	S & K.	50.		" Clouded in p.m.
" " "	" 18	7 00 a.m	27.18	56 5		43.5	Calm.		6	S & K S.			Clearing during night.
" "	" 18	7 00 p.m.	27.17	64.			S.	1	2	K & K S	58.		Fair. Sunny.
" "	" 19	6.00 a.m.	27.20	52.		41.	W.		9	S & K S.		Gloomy.	Dull night.
" "	" 19	7.00 p.m.	27.12	60.			Calm.		1	K.			Fair. K. 5.
" "	" 20	6.00 a.m.	27.15	50.		35.	"		1	C.			" Calm night.
" "	" 20	7 00 p.m.	27.00	60.			"		1	C S.		Fair.	" Very warm day.
" "	" 21	6.00 a.m.	27.08	48.		33.	"		1	C.		"	" night. Skin of ice.
" "	" 21	7.00 p.m.	26.93	65.			W.	1	5	K.	59 5	"	" Warm day.

Finlayson River	July	22	6.30 a.m.	26.98	59.		41.	Calm.		1	K & C.		Fair.	Fair. River fell 1 in.
East Branch Finlayson River	"	22	8.00 p.m	26.84	58.5			N.W.		0			"	" Warm.
" " "	"	23	7.00 a.m.	26.91	57.		40.	Calm.		1	K.		"	" night.
Finlayson River Valley	"	23	7.00 p.m.	26.51	72.			"		1	C & K.		"	" Very warm all day.
" " "	"	24	7.00 a.m.	26.60	67.		50.	S.	1	0			"	" night.
" Lake	"	24	7.00 p.m	26.80	74.			Calm.		0		64.		K. 1 greater part of day. Fair.
" "	"	25	7.00 a.m.	26.83	59.		41.5	"		0				Fair. S. wind 2 last night. Smoky.
" "	"	25	7.00 p.m.	26.84	74.	78.5		"		1	C.	65.	Fair.	N. wind 2. Blue sky.
" "	"	26	6.30 a.m	26.93	58.		52.	"		0			"	S. wind 1. Smoky. Fair.
" "	"	26	7.15 p.m.	26.79	72.			"		1	C S.	66.	Fair, smoky.	Fair. S. wind 1, a.m.; calm p.m.
" "	"	27	6.30 a.m.	26.72	58.		51.	E.	1	3	K S.		" "	" E. wind 1-2 all night.
Country west of Finlayson Lake	"	27	7.30 p.m.	25.84	70.			Calm.		1	K.			" K. 2-7.
" " " "	"	28	6.00 a.m.	25.74	50.		37.	"		0			Fair.	" K. 1-2.
" " " "	"	28	7.00 p.m.	26.46	69.			W.	1	1	C & K.		"	Smoky. K. 1-4.
" " " "	"	29		26.54	40.		46.	Calm.					"	Fair.
Pelly River	"	29	7.00 p.m.	26.88	64.			S.	1	4	C S.	61.	"	p.m. S. wind 2. Like rain.
" "	"	30	6.30 a.m.	26.93	55.		46.	Calm.		6	K & K S		Threatening	Fair. River fell 1 in.
" "	"	30	7.00 p.m.	26.87	55.	70.		"	.	10	S.	60.	"	Thunderstorm in evening. S. wind 1.
" "	"	31	7.00 a.m.	26.86	51.		43.	"		4	K.		Clearing.	Rain all night. Cleared 6 a.m.
" "	"	31	7.00 p.m.	26.84	55.5	62.5		S. W.	2	4	K.	59.	Fair.	Wind S.W. 2. K. 1-5.
" "	Aug.	1	6.30 a.m	26.84	43.		29.	Calm.		9	K.		Threatening.	Fair. K. 2-5.
" "	"	1	7.00 p.m.	26.87	54.			"		10	K S.	59.	Gloomy.	Wind W. 2. Showery. K. & K.S.
" "	"	2	6.00 a.m.	26.91	40.		40.	"		1	K & C.			Light sprinkle rain during night.
" "	"	2	7.00 p.m.	27.12	57.			Lt. var.		2	C & K S.	56.		Showers. Wind W 2. K & K.S.
" "	"	3	6.00 a.m.	27.25	33.		28.	Calm.		0				Fair night. River still falling.
" " Hooles Cañon	"	3	7.00 p.m.	27.28	49.			Lt. var.		9	K & S.	51.		" Clear. Wind N. 2.
" " " "	"	4	6.00 a.m.	27.22	50.		40.	N. E.	1	1	K.		Fair.	Cleared off last evening. Wind 3.
" " " "	"	4	7.00 p.m	27.42	51			N.W.	2	9	S.	53.	Gloomy.	Showers p.m. Wind N.W. 3, p.m.
" "	"	5	6.00 a.m	27.45	44.		37.	W.	1	10	S.		"	Gloomy night. River fell 2 in. Wind N.W. 2.
" "	"	5	7.00 p.m.	27.62	54.			Lt. var.		10	K S	52.5	"	W. wind. 3showers. Dull day.
" "	"	6	6.00 a.m.	27.70	47.		41.	E.		1	K S.			2 showers in night. K.S. 10-2.
" "	"	6	7.00 p.m.	27.81	58.			Calm.		3	K.	54.	Fair.	Wind W. 2. Sunshine p.m.
" "	"	7	6.00 a.m.	27.88	36.			"		1	K.		"	Calm. Fair. K. 1.
" "	"	7	7.00 p.m.	27.83	64.			"		0		57.	Smoky.	Fair wind N. & N.E. 2 to-day.
" "	"	8	5.10 a.m	27.63	51.		50.	W.	2	10	K & S.			K. & K.S. 0-6 p.m. River fell 1 in.
" "	"	8	7.00 p.m.	27.69	59.			W.	2	3	K.	57.	Fair.	Wind W. 2. Cleared up about 12.00.
" "	"	9	6.00 a.m.	27.99	45.		44.	Lt. var.		0			Very clear.	Wind W. 3.
" "	"	9	7.00 p.m.	28.19	58.			"		0		57.	Fair.	Showers. Wind 2. K. 0-6.
" "	"	10	6.00 a.m.	28.30	40.		34.	Calm.		1	C S.		Fog on river.	Fair.
" "	"	10	7.00 p.m.	28.28	60.			E.	1	9	K S.	56.	Gloomy.	S.C. 5. Light winds up & down river.
" "	"	11	6.00 a.m.	28.39	33.		38.	Calm.		1	C.		Fog on river.	K.S. 10-0.
Camp near Fort Selkirk	"	11	7.00 p.m.	28.43	62.			"		6	C S.	56.3	Fair.	C.K. 2-4. Light N.W. air.
" " "	"	12	7.00 a.m.	28.46	50.		46.	E.	1	10	S & K S		Threatening	Hazy and calm.
" " "	"	12	7.00 p.m	28.35	54.	78.		W.	1	4	C K.	56.		C. & K.S. 0-9. Dull day.
" " "	"	13	7.00 a.m.	28.38	50.		45.	S.	1	1	K S.			K.S. 8. Calm.
" " "	"	13	7.00 p.m.	28.30	65.	75.5		Calm.		1	K.	57.		" 1. " River fell 1 in.
" " "	"	14	7.00 a.m.	28.39	45.		38.	E.	1	1	K.			" 1. "
" " "	"	14	7.00 p.m.	28.33	63.	71.		Calm.		3	C.	56.5		C.S. 1-4. "

PLACE.	Date.	Hour.	Barometer corrected.	Ther. corrected. Air.	Max.	Min.	Direction of wind.	Force o wind	Amt. of cloud.	Kind of cloud.	Temperature of Water.	Weather at time.	Weather during last interval.
				°	°	°							
Camp near Fort Selkirk	Aug. 15	7.00 a.m.	28.26	48.		48.	Calm.	..	6	C K.	....	Threatening.	Gloomy. Calm. C S & K 5, River fell 1 in.
" " "	" 15	7.00 p.m.	28.28	70.5	81.5	...	"	....	3	C.	58.	Smoky.	Sultry. C. 1-4.
" " "	" 16	7.30 a.m.	28.35	52	..	40.	"	...	5	C K&C S.	.....	"	Calm. C S & K 4. Very thin clouds.
" " "	" 16	7.00 p.m.	28.31	62.	70.	...	"	....	3	C & K.	57.	"	" C & K 5 all day. River fell 1 in.
" " "	" 17	8.30 a.m.	28.34	59.	....	48.	"	...	3	K.	....	Fair.	Cloudy. C S & C K 4-6.
" " "	" 17	7.00 p.m.	28.29	69.	80.	....	S.E. Air.	...	0	....	50.	"	Fair. Clear.
" " "	" 18	6.30 a.m.	28 36	39.	....	38.	Calm.	....	1	C S.	.....	"	" Very clear night.
Lewes River	" 18	7.00 p.m.	28.13	65.	....	....	"	....	1	C.	59.	"	Wind 1 S. Clear p.m.
" "	" 19	5.30 a.m.	28 24	47.	....	45.	"	...	1	K S.	.....	"	Overcast.
" "	" 19	7.00 p.m.	28 22	56.	....	..	"	..	10	S & K.	56.	Rainy.	Rain from S. p.m.
" "	" 20	5.45 a.m.	28.34	47.	....	42.	"	....	10	S.	.....	Foggy	Stopped raining last evg. Calm. Ugly.
" "	" 20	7.00 p.m.	28.32	55.	....	..	"	..	0	....	56.	Fair.	Overcast till 4 p.m. Wind S.E. 1.
" "	" 21	5 45 a.m.	28.41	35.	...	34.	"	...	0	....	.....	Dense fog.	
" "	" 21	7.00 p.m.	28.29	65.	..	...	"	....	5	C & K.	56.	Fair.	K. 3. Wind 1 S.E. Warm day.
" "	" 22	6.00 a.m.	28.41	45.	....	44.	"	...	0	....	.....	Fair. clear.	Light showers during night.
" "	" 22	7.00 p.m.	28 32	56.	...	....	"	.	1	K.	56.	Fair.	Sunny. Wind S S.W. 1.
" "	" 23	6 00 a.m.	28.10	33.	....	....	"	....	0	....	.....	Foggy.	
" "	" 23	7.00 p.m.	28.09	59.	...	....	"	..	1	C.	56.	Fair.	Calm. C S 5.
" "	" 24	6.00 a.m.	28.08	8.	....	31.	"	....	6	K.	.....	Clear.	Clear. Wind S. 1.
" "	" 24	7 00 p.m.	27.89	64.	...	....	"	...	0	....	56.	....	Hot day.
" "	" 25	6.00 a.m.	27 95	52.	....	51.	"	..	10	K S.	.....	Drizzling.	Rainy, light.
" "	" 25	7.00 p.m.	27.92	49	..	....	S.	1	10	K & S.	55.	Gloomy.	Clouded all day. Raining half time.
" "	" 26	6.00 a.m.	27.91	46.	.	44.	S. E.	1	10	K & S.	.....	"	Showery. Wind S. 1.
" "	" 26	7.00 p.m.	27.82	52.	....	....	"	1	10	K & K S.	54.	"	K & K S 10 all day. Cool wind S.E. 1.
" "	" 27	6 00 a.m.	27.83	41.	....	37.	Calm.	....	9	K S.	.....	Fog.	K S 10. Calm.
" "	" 27	7.00 p.m.	27 82	53.	....	....	"	....	4	K S	55.	Fair.	Showery. K. 5-6. Warm sun.
" "	" 28	6.00 a.m.	27 93	33.	...	32.5	E.	1	1	C.	.....	Fog	K 4-0.
" "	" 28	7.00 p.m.	27 86	46.	....	....	Calm.	...	1	K	54.	Fair.	Sunny. K. 3.
" "	" 29	6 00 a.m.	27.92	30.	...	28.5	"	....	0	....	.....	Fog.	Clear. Calm.
" "	" 29	7.00 p.m.	27.86	55.	....	....	S.	1	6	K.	51.	Fair.	Fair wind S. 3. K S. 5-8.
" "	" 30	6.00 a.m.	.....	36.	...	23.5	Calm.	....	8	S & C K.	.....	Fog.	C K & S 6.
" " mouth of Tes-lin-too.												Gloomy.	Showery. K & S 10. Wind S.3. Cold.
	" 30	7.00 p.m.	27.72	55.	....	....	S.W.	3	10	S & K S.	52.	"	" S & K S. 10 " 3.
" " " "	" 31	7.30 a.m.	27.70	54.		49.	S.	4	10	S & K S.	.....	Fair.	K S & C S 8. Wind S. 3 all day.
" " " "	" 31	7.00 p.m.	27 72	57.	60.	....	S.	3	5	C K.	52.	Fair.	R S & C S 8. Wind S. 3 all dap.
" " " "	Sept. 1	5.30 a.m.	27.72	52.	....	49.5	Calm.	....	10	S.	.....	Light rain.	Showery. Wind died out last night.

Lewes River	Sept.	1	7.00 p.m.	27.63	57.	...	...	S. W.	2	8	S & K S.	52.	Fair.	Wind N.E. 1 a.m., S. 2 p.m.
" "	"	2	5.30 a.m.	27.78	32.	...	30.	Calm.	...	0	...		Fog.	Fair. Clear.
Foot of Lake Labarge	"	2	7.00 p.m.	27.88	41.	...	...	"	...	3	K.	53.	"	K. 1-6. Wind S. 2.
" " "	"	3	6.00 a.m.	27.92	33.5	...	27.5	N.	1	6	C S.	...	Fair.	Clear. Calm.
Lake Labarge	"	3	7.00 p.m.	27.71	54.5	...	...	S.	3	3	C.	51.5	"	C. & S. 1-5. Wind S. 3 all day. Hazy sunshine.
" "	"	4	5.30 a.m.	27.83	39.5	...	36.	Lt. var.	...	10	C S & K.	...	"	C. 5. Wind died out early last night.
Near head of Lake Labarge	"	4	7.00 p.m.	27.60	56.	...	...	W.	2	5	K & S.	49.5	"	C. clouds coming rapidly from W. p.m.
" " " "	"	5	6.00 a.m.	27.88	44.	...	42.	W.	1	10	K S.	...	Light rain.	Showery a.m. W. wind 3 for 1 hour.
Lewes Riv., below Tahkheena R.	"	5	7.00 p.m.	27.87	53.	...	...	Calm.		3	C S.	54.	Fair.	Fair. C.K. 3. Wind S. 1., p.m.
" " " "	"	6	6.00 a.m.	27.67	50.	...	49.	S.	3	10	S & K.	...	Gloomy.	" S. 10 wind latter part of night.
" " White Horse Rapid	"	6	7.00 p.m.	27.54	53.	...	..	Calm.	..	8	K & C.	53.5	Fair.	K.C. 1-4. Wind S. 4.
" " "	"	7	6.00 a.m.	27.72	42.	...	41.	"	..	9	K S.	...	"	Calm. K. 2-6. Light rain this a.m.
" " below cañon	"	7	7.00 p.m.	27.65	48.5	...	...	S.	2	10	S.	53.	"	K. 0-5. Wind S. 1.
" " " "	"	8	6.00 a.m.	27.67	44.	...	42.5	Lt. var.	..	6	K.	...	"	Fair. Wind S.W. 1.
" " head of "	"	8	7.00 p.m.	27.57	51.	...	...	S. W.	1	6	K S.	53.5		
" " " "	"	9	6.00 a.m.	27.49	38.	...	34.	Lt. var.	...	9	K.	...	Gloomy.	K. 2-0.
" "	"	9	7.00 p.m.	27.54	18.	...	...	N.W.	2	10	S.	...	"	Wind p.m. N.W. Cool day.
" "	"	10	7.00 a.m.	27.75	41.5	...	37.	Calm.	...	10	S.	...	Drizzling.	Rained a little. Calm. Snowed on mts.
Lake Marsh	"	10	7.00 p.m.	27.76	41.5	...		Lt. var.	...	10	S & K S.	52.	Gloomy.	Showery. Wind W. 1. Cool.
" "	"	11	6.20 a.m.	27.83	39.	...	32.	E.	1	10	S & K S.	...	"	Overcast all night. Calm.
Tagish Houses	"	11	7.00 p.m.	27.69	42.	...	...	Calm.	...	1	K.	49.5	Fair.	K S & K 8-2, a.m.; p.m., Wind W. 2. C. clouds.
" "	"	12	6.00 a.m.	27.60	29.	...	27.	"	...	10	S.	...	Gloomy.	K S 1. Calm. Clouded over this a.m.
Tagish Lake,	"	13	6.30 a.m.	27.69	36.	...	31.	Lt. var.	...	3	C S & K.	...	Fair.	Wind W. 3.
Windy Arm	"	13	7.00 p.m.	27.76	33.	...	...	"	...	1	K S.	48.5	"	K S 4-0. A.m. wind N. 1; p.m. calm.
" "	"	14	6.00 a.m.	27.88	26.5	...	25.	Calm.	...	0	...	...	"	Clear. Calm.
Bennett Lake	"	14	7.00 p.m.	27.83	36.	...	...	N.	1	0	...	46.5	...	K. 1. Hot sun. Wind S. 2 all day.
" "	"	15	6.00 a.m.	27.83	29.	...	26.	S.	1	1	K.	...	Fair.	Clear. Calm.
" "	"	15	7.00 p.m.	27.75	43.	...	..	N.	3	8	K.	45.5	"	K & C K 1 3. Low wind N. 2, high wind W.
" "	"	16	6.30 a.m.	27.75	40.5	...	39.	N.	1	10	K S.	...	Gloomy.	K 8. N. 2 wind all night.
Lake Lindeman	"	16	7.00 p.m.	27.75	40.	..	..	N.	1	10	K S.	45.	...	K S. 6-10. Wind S. 1, a.m.; N. 1, p.m.
" "	"	17	7.00 a.m.	27.74	41.		29.	S. W.	1	8	K.	...	Fair.	K. 10-6. Calm.
" "	"	17	7.00 p.m.	27.72	37.	58.		S.	1	1	K.	45.	"	K. 10-4. High wind N., low wind S. 1.
" "	"	18	7.00 a.m.	27.75	36.	...	19.	Calm.	...	0	...	.	"	Clear. Calm. Light fog on water.
" "	"	18	7.00 p.m.	27.71	32.	51.	..	N. E.	1	1	C.	45.	"	" all day. " var. wind.
" "	"	19	6.00 a.m.	27.75	21.	...	18.	N. E.	1	0	...	...	"	Fair; clear. " fog on water.

(2) OBSERVATIONS AT TELEGRAPH CREEK, STIKINE RIVER, B. C., DURING PORTIONS OF THE YEARS 1881 TO 1886, BY J. C. CALLBREATH.

Date.	Minimum Temperature	Remarks.	Date.	Minimum Temperature.	Remarks.
1881.	°		1881.	°	
Oct. 2	23	Coldest night yet.	Dec. 21	2	
3	......	Heavy frost last night.	22	10	
8	12		23	-2	
9	7	First ice running on river.	24	-2	
10	14		25	15	
11	22		26	-2	
12	20		27	-2	
13	......	Little frost last night.	28	-2	
14	......	No frost this morning.	29	-7	
15	23		1882.		
16	14		Jan. 1	-4	
17	10		2	-17	
18	7		3	-14	
19	10		4	-13	
20	21		5	-12	
21	30		6	5	
22	......	No frost last night.	7	6	
23	......	Weather mild.	8	6	
24	......	" "	9	8	
25	......	" "	10	6	
26	......	" "	11	8	
27	......	" " 9 p.m., 45°	12	16	
28	26		13	......	Heavy thaw.
29	25		14	8	
30	33		17	30	
31	28		18	22	
Nov. 1	20		19	22	
2	32		20	16	
3	26		21	7	
4	......	No frost last night.	22	-4	
5	32		23	-15	
6	25		26	-26	
8	31		27	-30	
9	26		28	...	Mild.
10	29		29	27	
11	24		30	6	
12	16		31	13	
13	12	2 in. snow on range at Tahltan.	Feb. 1	19	
14	8		2	5	
15	-13	3 or 4 in. snow on range at Tahltan.	3	8	
16	-17		4	15	
17	-4		7	-1	
20	......	Mild.	8	-9	
22	-7		9	-12	
23	4	Mild all day.	10	-28	
24	8	8 in. snow on range at Tahltan.	11	-28	
25	32		12	20	
26	34		13	0	
27	20		14	0	
28	20		15	-27	
29	15		16	-32	
30	10		17	-20	
Dec. 1	20		18	......	9 a.m., -2°
2	20		19	......	Thawing.
3	2		20	4	
4	0		21	30	
5	4		22	12	
6	12		23	-8	
7	7		24	-1	
8	3		25	-2	
9	-2		26	0	
10	0		27	......	Mild.
11	-13		28	5	
12	-29		March 1	10	
13	-20		2	-6	
14	-18		3	-16	
15	-4		4	-22	
19	6		5	-13	
20	24		6	10	

Date.		Minimum Temperature.	Remarks.
1882.		°	
March	7	20	
	8	23	
	9	—4	
	10	—4	
	11	7	
	12	22	
	13	7	
	14	6	
	15	—6	
	16	13	
	17	—5	
	18	—18	
	19	—17	
	20	—10	
	22	—19	
	23	2	
	24	15	
	25	22	
	26	8	
	27	15	
	29	—8	
	30	—12	
	31	10	
April	1	14	
	2	10	
	3	20	
	4	15	
	5	14	
	7	12	
	9	22	
	10	23	
	11	24	
	13	24	
	14	25	
	15	33	
	16	29	
	17	30	
	20	9	
	21	30	
	22	16	
	23	11	
	24	27	
	25	16	
	26	17	
	27	19	
	28	26	
	29	25	
	30	26	
May	1	27	
	2	28	
	3	34	
	4	34	
	5	33	
	7	32	
	9	26	
	10	33	
	11	42	
	13	28	
	14	34	
	15	30	
	16	28	
	17	35	
	18	38	
	19	26	
	21	29	
	22	29	
	23	......	No frost.
	24	......	" "
Sept.	29	22	Coldest night of season, bright clear day.
	30	20	Wind N., bright and clear all day.
Oct.	1	24	Wind N.
	3	19	

Date.		Minimum Temperature.	Remarks.
1882.		°	
Oct.	4	19	
	6	......	Bright, fine day.
	7	21	
	8	30	Cloudy, light sprinkle rain a.m.
	10	33	" raining a little all day.
	11	36	
	13	30	
	14	24	
	16	30	Fine, clear day, strong wind up river.
	17	30	Cloudy and calm.
	18	32	Rained hard in eve., drizzling all day.
	19	35	
	21	32	Snowing this morn., melting as it fell.
	28	......	Mild and pleasant.
	31	12	Ice running in river for first time.
Nov.	1	14	
	2	20	Wind up river since noon.
	3	24	Fine, mild day.
	5	15	Mild and pleasant; bright all day; less than 1 in. snow fell yesterday
	6	12	
	7	17	Mild and calm all day.
	8	18	Overcast, light mist; little or no ice in river.
	9	3	
	10	2	Calm, mackerel-sky clouds moving up river.
	11	22	Mild and calm all day.
	12	26	Snowed a little.
	13	19	Clear and calm all day.
	14	24	Light floating clouds; calm and mild all day.
	15	17	Commenced raining 2 p.m.
	16	32	Rained all night; snowed for 1 hour after daylight; cleared off.
	17	30	Mild and pleasant all day; wind up river.
	18	25	Mild and pleasant; light snow in evening.
	19	21	Bright, calm day.
	20	11	Partly clear.
	21	—5	Clear and calm.
	22	—10	" " "
	23	—6	Partly overcast a.m., p.m. mild, calm, overcast.
	24	6	Lightly overcast, calm.
	25	7	Snowed a little this a.m.
	26	20	Lightly clouded all day, mild.
	27	8	Overcast, snowing a little, mild all day.
	28	7	Clear and mild all night.
	29	3	Misty, began snowing from N.E. 4 p.m.
	30	15	Snowed 3 in.; river nearly closed.
Dec.	1	6	Lightly overcast.
	2	7	Mild day.
	3	14	Light overcast, calm all day.
	4	14	Hazy and calm.
	5	14	" " "
	6	—1	
	7	0	Mild and calm.
	8	1	Mild, overcast; lt. snow p.m.
	9	11	Lightly overcast, mild and calm.
	10	8	Partly clouded; snow squalls.
	11	—7	Cold all day; wind down river.

Date.		Minimum Temperature.	Remarks.
1882.		°	
Dec.	12	—11	
	13	—28	Cutting N. wind; not above —20° all day.
	14	......	9 a.m., —16°; 5 in. fine snow all day.
	15	—11	Snowed about 8 inches.
	16	6	Little snow during night; growing warmer.
	17	21	Overcast, wind E.
	18	6	Overcast, as usual this mild weather.
	19	—4	
	22	......	This evening 33°.
	23	20	
	24	12	Mild and pleasant all day.
	25	.....	10 a.m., 34°.
	26	23	Misty, sprinkle of snow, mild and calm.
	27	12	Clear, mild and pleasant all day.
	28	5	Clear; 15 in. snow on Tahltan range.
	29	—10	Clear and calm.
	30	—14	" " "
	31	—4	Mild and calm.
1883.			
Jan.	1	4	" " "
	2	0	
	3	......	9 p.m., —3°.
	4	......	8 a.m., —11°.
	5	—16	Clear; wind N.
	6	—20	Clear and calm.
	7	—16	Mild all day; clear.
	8	0	
	9	—6	Overcast.
	10	......	8 a.m., 5°.
	11	8	
	12	—11	Mild and calm all day.
	13	—9	
	14	......	8 a.m., 5°.
	15	0	Calm.
	16	—17	Clear and calm; cold all day.
	17	—24	
	18	—18	" " " growing milder.
	19	—8	
	20	2	Mild and calm.
	21	17	Calm all day.
	22	24	Lightly overcast, squally.
	23	16	Mild and squally.
	24	10	Misty overhead; calm.
	25	5	Calm; lightly overcast.
	26	—2	Lightly overcast and calm.
	27	......	11 p.m., 0°.
	28	0	Mild and calm.
	29	10	" " " partly overcast.
	30	—3	
Feb.	1	......	Weather milder.
	2	......	10 p.m., —24°; clear.
	3	.....	11 p.m., —22°.
	4	......	10.30 p.m., —10°; clear.
	5	—13	Lightly overcast; cold and clear.
	6	—10	Clear.
	7	—4	
	8	—3	Lightly overcast.
	9	—2	Clear and calm.
	10	—4	Clear; snowed a little.
	11	12	Overcast a.m.: strong E. wind, clear and calm p.m.
	12	0	Strong N.E. wind; clear.
	13	—20	Clear; N. wind.
	14	—28	Clear and calm.
	15	—23	Lightly overcast and calm.
	16	—10	" " sprinkling snow.

Date.		Minimum Temperature.	Remarks.
1883.		°	
Feb.	17	5	Overcast; a little snow.
	18	10	Mild and calm; snowed 2 in. last night.
	19	7	Calm.
	20	—2	Clear and calm.
	21	—3	Clear.
	22	.....	10 p.m., 5°.
	23	—1	Calm and partly clouded.
	24	9	Cloudy.
	25	—1	10 a.m., thawing—first thaw of season.
	26	33	Thawing: clear all day.
	27	35	Thawed all night.
	28	22	Bright and warm.
March	1	9	Clear.
	2	......	Warm day.
	3	25	Wind N.E.
	4	11	Bright, clear.
	5	11	Bright.
	6	7	Clear.
	7	15	Clear, warm day; thawing in shade.
	8	21	Clear, bright; strong wind up river.
	9	28	Clear.
	10	18	Clear and warm.
	11	22	
	12	28	
	13	26	
	14	24	
Oct.	13	......	Weather mild.
	14	......	" "
	15	......	" " overcast.
	16	......	Very mild.
	17	.....	Mild and calm.
	29	......	About 12°; weather moderate; little ice running in river.
Nov.	1	—5	Coldest night of season; much ice in river.
	2	5	9 p.m., 8°.
	3	4	10 p.m., 32°.
	4	27	Snowed 1 in.; mild day.
	5	26	" 2 " last night.
	6	27	
	7	16	
	8	10	
	9	15	Snowing lightly a.m.; p.m. clear.
	10	—3	Lightly overcast.
	11	6	Mild, hazy, calm.
	12	......	8 a.m., —4°; clear, calm.
	13	—12	Moderating; calm.
	14	—3	Clear and calm.
	15	10	Mild and calm,
	16	12	Clear; wind down river.
	17	......	8 a.m., 27°; river closing fast.
	18	25	Mild and overcast.
	19	26	
	20	28	Clear.
	21	......	8 a.m., 24°.
	22	13	
	23	—7	Clear; N. wind.
	24	—16	" " "
	25	—20	Clear and calm.
	26	—25	" " "
	27	—27	Clear and calm a.m.; p.m. hazy.
	28	—12	Snowed a little last night; clear day.
	29	—11	
	30	—3	Mild; overcast all day.
Dec.	1	14	Snowed and rained a little to-day.
	2	31	

Date.		Minimum Temperature.	Remarks.
1883.		°	
Dec.	3	9	Hazy, calm.
	4	9	Mild.
	5	16	Mild.
	6	—10	Calm, hazy, mild.
	7	......	8 a.m., 22°; snowed 1 in. last last night.
	8	13	Calm and clear.
	9	16	Misty; snowed a little.
	10	26	Wind S.
	11	26	Clear and calm.
	12	21	Clear.
	13	7	Mild all day.
	14	12	Snowed a little all day.
	15	......	9 a.m., 22°; snowed a.m.; rain p.m.
	16	......	9 a.m., 42°; clear; strong S. wind.
	17	......	9 a.m., 34°.
	18	......	9 a.m., 24°; little snow.
	19	14	
	20	18	
	21	9	Clear and calm.
	22	—1	Clear and hazy.
	23	......	9 a.m., —4°.
	24	......	9 a.m., —11°.
	25	—17	Clear and calm.
	26	—14	
	27	—9	Clear.
	28	—26	Clear; N. wind.
	29	—30	Clear and calm.
	30	—33	
	31	......	6 a.m., —1°; wind N.E.
1884.			
Jan.	1	—6	Clear and calm.
	2	—10	Clear.
	3	—14	Clear; N. wind.
	4	—20	Hazy all day; 10 p.m., —6°.
	5	—6	Hazy; 10 p.m., —2°; lt. snow.
	6	—15	
	7	—6	
	8	......	9 a.m., 5°.
	9	......	" " 8°.
	10	......	" " 10°; snowed 1 inch.
	11	......	" " 22°; hazy, calm.
	12	15	Snowed a little last night.
	13	7	
	14	20	
	15	0	
	16	37	Strong southerly wind; thawing.
	17	9	Clear and calm.
	18	0	Hazy, calm.
	19	—10	Clear and calm.
	20	0	Partly overcast.
	21	14	Mild and hazy; a little snow.
	22	20	Clear and calm.
	23	22	Mild all day.
	24	20	" " "
	25	23	Snowed about 2 in. last night.
	26	6	N.E. wind.
	27	—17	Clear and calm.
	28	—20	" " "
	29	—21	Clear; wind up river.
	30	—5	Thawing all day; 10 p.m., 30°.
Feb.	1	—5	Snowed 4 in. last night; strong N.E. wind.
	2	—19	
	3	—21	
	4	—5	
	5	—7	Clear.
	6	—5	" and calm.
	7	—7	" strong wind down river.
	8	—15	" and calm.
	9	—13	" " "

Date.		Minimum Temperature.	Remarks.
1884.		°	
Feb.	10	—18	Clear and calm.
	11	—18	" " "
	12	—17	" " "
	13	—15	" " "
	14	—9	" " "
	15	—23	Calm.
	16	—19	Strong north wind; clear.
	17	—21	Strong N.E. wind; lt. snow; overcast.
	18	—20	Clear; N. wind.
	19	—30	Clear and calm; coldest night of winter.
	20	—25	Calm.
	21	—25	Clear and calm; p.m. overcast.
	22	—5	Snowed a little.
	23	10	Lightly overcast; little snow.
	24	40	Strong S. wind; thawing.
	25	24	
	26	35	Rained hard during night.
	27	30	Little hazy.
	28	12	
	29	10	Clear, calm.
March	1	15	" "
	2	20	Clear.
	3	20	Overcast: strong N.E. wind all day.
	4	—2	Clear; N. wind.
	5	—7	
	6	—8	
	7	10	
	8	6	Clear and calm.
	9	—3	" " "
	10	—4	" " "
Oct.	18	......	Ice commenced running in R.
	19	12	
	20	......	Not much ice running to-day.
	21	......	More " " "
	22	......	Ice running thick; little frost last night; thawed all day.
	23	......	Ice running thick; froze a little last night; thawing this a.m.
	24	......	Snowing this evening.
	26	......	Mild; snowing a little; river almost clear of ice.
	27	......	Mild; no ice running.
	28	20	Cloudy; light snow.
	29	18	Overcast; light snow; good deal of ice running.
	30	12	Much ice running; mild to-day.
	31	12	Dry, mild and clear.
Nov.	1	7	Clear; coldest night of season so far.
	2	14	Lightly overcast; mild and pleasant.
	3	16	Mild and pleasant day.
	4	24	Snowing this a.m.
	5	30	Snowed 2 in. last night; thawing this morn.; snow at Thaltan range nearly 1 ft. deep.
	6	24	Clear.
	7	28	
	8	29	
	9	29	
	10	30	
	11	32	Snowing at noon; turned to rain and sleet.
	12	38	Raining.
	13	32	Clear; no ice in river.
	14	24	Clear and calm.
	15	14	
	16	18	Overcast.
	17	20	Misty and calm; snowed a little in evening.

Date.	Minimum Temperature.	Remarks.
1884.	°	
Nov. 18	32	Clear.
19	22	A little snow during day,
20	21	Overcast, calm.
21	11	Hazy and calm.
22	13	Mild " "
23	16	Clear.
24	14	Hazy and calm.
25	20	Snowed about 2 in. last night.
26	26	Nearly clear.
27	29	Hazy.
30	36	Rained hard all day.
Dec. 1	31	Clear a.m. ; clouded and raining p.m.
2	.....	8 a.m., 34° : 1 p.m., raining; 3 p.m., cleared.
3	30	Clear.
4	24	Snowed about 2 in. this eve.
5	24	Clear.
6	20	Misty and cloudy ; wind S.W.
7	.....	10 a.m., 42°.
8	30	Clear and calm.
9	21	Lightly overcast.
10	21	Clear.
11	12	Clear : wind down river.
12	7	Clear,
13	3	Lightly overcast.
14	3	Clear ; N. wind.
15	—15	Clear : N. wind ; below —12° all day.
16	—16	Clear.
17	—4	Strong easterly wind.
18	—8	Clear ; strong wind down river; crossing on ice to-day.
19	—12	Clear : N. wind.
20	—15	" " "
21	—20	Strong ; N.W. wind a.m. ; calm p.m.
22	—20	Little wind.
23	—10	Overcast.
24	—5	Clear.
25	—15	"
26	—22	Clear, strong north wind.
27	—22	
28	—[illegible]	Clear.
29	—20	Clear and calm.
30	—14	" " "
31	—7	Lightly overcast,
1885.		
Jan. 1	—3	Calm and hazy.
2	—8	Lightly overcast.
3	5	Partly clear.
4	—6	Overcast ; snowing.
5	17	
9	......	Mild and calm.
10	......	Snowed 4 in. last night ; light snow to-day.
11	......	Clear and colder this morning.
12	......	10 p.m., —1[illegible]° : below zero all day.
13	—22	
14	—30	Clear.
15	—32	" N. wind.
16	—32	" and calm.
17	—22	" " "
18	—28	" " "
19	—5	Hazy ; light snow last night.
20	3	Calm. misty.
21	10	Snowed about 3 in. last night ; clear and calm.
22	—6	Hazy, calm.
23	6	" "
24	10	" "
25	16	Rained all p.m.
28	......	Mild.

Date.	Minimum Temperature.	Remarks.
1885.	°	
Jan. 30	......	Light snow.
31	......	Mild and calm.
Feb. 1	19	
2	22	Calm
3	25	Lightly overcast.
4	30	Overcast, calm.
5	11	" "
6	10	Cloudy ; E. wind.
7	—2	Clear and calm.
8	—9	" " "
9	—15	" " "
10	—5	Calm and overcast.
11	10	" " misty.
12	10	Clear and calm.
13	13	Hazy " "
14	14	" " " lt. snow in eve.
15	20	Clear
16	......	10 p.m., 15°.
17	4	
18	—9	Clear and windy.
19	—16	" " calm.
20	—15	" " "
21	—5	Overcast.
22	19	Thawing in shade at noon.
23	29	Heavy thaw all day.
24	20	Clear and calm.
25	20	Clear ; thawing all day.
26	27	" " " "
27	12	Wind N.E.
28	32	Sleet this p.m.
March 1	30	Clear ; maximum temp. 40° in shade.
2	26	Clear and calm.
3	20	Clear all day.
4	10	Clear and calm.
5	10	Lightly overcast : clearing.
6	22	Overcast, calm ; snowing at 2 p.m.
7	38	Raining hard.
8	34	Overcast, calm.
9	16	Murky. calm.
10	16	Snowed a little this evening.
11	21	Clear ; strong S.W. wind.
12	26	Snowing all day.
13	24	8 in. snow fell yesterday ; last night clear and calm.
14	26	Clear.
15	34	Clear : heavy thaw.
16	22	Clear and calm.
17	12	" " "
18	12	" " "
19	......	" " "
20	20	" " "
21	......	10 p.m., 28°.
22	10	Clear and calm.
23	16	" " "
25	32	
26	26	
30	......	No frost last night ; cloudy ; strong wind up river.
31	34	Clear ; wind up river.
April 1	30	Warm ; S. wind all day.
2	33	Overcast in morning ; raining p.m.
3	......	Rained and snowed most of night ; 2 in. went off this p.m. ; bright.
4	......	Frost last night.
5	35	Clear.
6	18	"
7	22	Cloudy.
8	......	No frost last night ; strong S.W. wind.
9	30	

Date.	Minimum Temperature.	Remarks.
1885.	°	
April 10	28	Clear; strong wind up river.
11	31	
12	31	High winds.
13	30	Little wind; some snow squalls.
14	.....	Not much wind to-day.
15	25	
16	16	
17	10	
18		Hard frost.
19	.....	No frost last night.
20	27	
23	28	
Nov. 4	20	
7	26	Strong S.E. wind.
8	22	First ice running in river.
9	5	Clear; good deal of ice running.
10	20	Calm.
11	22	Calm; spitting snow; cloudy.
12	18	Calm and clear.
13	14	Clear; snowed a little last night.
14	19	A litttle ice running.
15	22	Calm.
16	18	Overcast, calm.
17	22	" "
18	16	Calm; snowing a little.
19	14	Clear.
20	12	
21	7	Clear.
22	6	Clear; river open yet; very little ice running.
23	15	Hazy, calm.
24	21	River entirely free of ice; hazy.
25	12	Hazy.
26	10	Hazy p.m. clear.
27	12	Clear and calm.
28	10	Hazy and calm.
29	31	Snowing 9 a.m., p.m. thawing.
30	28	9 in. snow fell during night.
Dec. 1	7	Clear, calm.
2	—2	
5	.....	Snowing a little.
6	22	Cloudy.
7	20	Overcast.
8	12	Clear.
9	—8	Clear and calm.
10	—18	" " "
11	0	Snowed a little.
12	8	Hazy, calm all day; snowed little in evening.
13	10	Snowed 5 in. last night.
14	20	
15	14	Hazy, calm.
16	12	Clear.
17	3	Clear and calm.
18	3	" " "
19	—6	Clear.
20	—10	Clear; river closing from edges.
21	—16	
22	4	Clear and calm.
23	—4	" " "
24	.....	8 a.m., —4°.
25	0	
26	10	Thawing; raining in evening.
27	36	
28	28	Cloudy.
29	13	Cloudy; snowed 1 in.; wind up R.; wind down R. in eve.
30	—6	Clear (?); snowing a little all day.
31	—13	Clear.
1886.		
Jan. 1	—4	Snowed 2 in.; strong wind up R.
Jan. 2	18	Snowed 2 in.
3	—2	Wind N.E.
4	-9	Snowed 2 in.
5	—26	Clear.
6	—32	Clouded up p.m.; snowed 2 in.
7	—10	Clear.
8	—6	Calm.
9	4	Clear.
10	6	Overcast; snowed a little in evening.
11	16	Snowed about 2 in.
12	20	Snowed 1 in.; calm and clear.
13	—6	Clear and calm.
14	—17	" " "
15	.....	8 a.m., —10°; clear; wind N.W.
16	—14	
17	.....	8 a.m., 20°; clear.
18	—8	Very clear.
19	—14	N.E. wind all day; clear.
20	—23	Very clear; N. wind.
21	—26	Clear.
22	—30	Clear and calm.
23	.....	9 a.m., 14°.
24	—16	Blew a gale all night.
25	—31	
26	—36	Hazy.
27	—22	"
28	—6	
29	—10	Snowed 2 in.
30	—12	Clear.
31	—6	Clear and calm.
Feb. 1	—10	
2	—2	Overcast; a little snow.
3	0	Snowed about 4 in.
4	—2	" a little.
5	22	" 2 in
6	34	Rained all night; snow in eve.
7	22	Clear.
8	18	misty.
9	20	Blowing a gale; snowed 6 in.; drifting badly.
10	—2	Clear; evening snowing.
11	......	8 a.m., 12°; snowed a little; clear.
12	—2	Lightly overcast.
13	—10	
14	—10	Clear and calm.
15	—2	Snowed 2 in.; rained a little p.m.
16	.....	9 a.m 28°; max., 42°; much rain.
17	34	Strong S.W. wind; much rain
18	......	8 a.m., 36°; raining hard most of night and to-day.
19	......	8 a.m., 36°.
20	38	Max., 44°; cloudy and raining.
21	36	Rained nearly all night; clear to-day.
22	27	Overcast; snowed a little.
26	......	10 p.m., 9°; very clear.
27	0	Clear and calm.
28	0	
March 1	8	Clear.
2	18	Overcast; p.m. snowing.
3	28	Cloudy.
4	20	Overcast.
5	14	Hazy and calm; eve. clear.
6	8	Clear.
7	....	10 p.m., 22°.
8	18	Cloudy and calm.
10	24	Thawing all day.
11	30	Clear.
12	30	Cloudy most of day.
13	24	

Date.	Minimum Temperature.	Remarks.
1886.	°	
Mar. 14	30	Heavy thaw.
15	27	Wind N.E.; snowed 1 in.
16	4	Clear; wind N.E.
17	−4	
18	16	
19	12	
20	10	
23	8	Cloudy most of day.
24	12	
25	18	Clear; freezing in shade.
26	20	Strong N.W. wind; thawing.
27	26	Wind up river; thawing.
29	......	No frost; cloudy.
30	28	Calm.
31	28	
April 1	30	Overcast.
2	......	No frost; overcast and foggy.
3	......	No frost.
5	20	
1886.	°	
April 6	18	
7	20	
8	30	
9	31	Clear.
10	30	
11	......	No frost.
12	27	
13	28	Clear.
14	......	No frost.
15	20	Clear.
16	30	Clear; clouded up in evening.
17	......	No frost.
18	......	" "
20	......	Frost last night.
21	......	No frost last night.
22	......	Finished ploughing.
23	......	Pack-train off to range.
23	......	Canoes arrived to-day.

(3) OBSERVATIONS AT LAKETON, DEASE LAKE, B.C., DURING PORTIONS OF THE YEARS 1878 TO 1882, BY MR. J. CLEARIHUE.

Date.	Minimum Temperature.	Direction of Wind.	Remarks.
1878.	°		
Nov. 1	0	S.W.	Mild and cloudy.
2	0	S.W.	Mild and clear.
3	18	S.W.	Raining.
4	22	N.W.	Heavy snowfall.
5	0	S.	Mild and clear.
6	0	S.	Mild and cloudy.
	20	S.	Mild; sunshine.
	14	S.	" "
	0	S.	Rain in afternoon.
10	0	S.	Heavy snowfall at night.
11	14	N.W.	Bright and clear.
12	10	N.W.	" " "
13	10	N.W.	" " "
14	12	N.W.	Cloudy, stormy afternoon.
15	16	N.W.	Bright and clear.
16	14	N.W.	Light snowfall.
17	18	N.W.	" "
18	18	S.W. strong.	Drifting all day.
19	0	S.	Cloudy; mild in p.m.
20	0	S.	Snowing.
21	20	S.	Cloudy.
22	18	N.W.	Snowing.
23	10	N.W.	Cloudy.
24	20	S.W.	Heavy snowfall.
25	10	S.W.	Mild, cloudy.
26	18	S.W.	" "
27	8	W.	Cloudy.
28	10	W.	Bright and clear.
29	10	W.	" " "
30	12	W.	" " "
1	12	S.W.	Snowing p.m.
2	20	S.W.	Mild, bright and clear; heavy snow at night.
	10	S.W.	Bright and clear.
1878.	°		
Dec. 4	12	N.W.	Bright and clear.
5	0	N.W.	Cloudy.
6	0	N.W.	"
7	12	S.	"
8	8	S.	Lake frozen in front of town.
9	1	N.W.	Bright and clear; skating on ice.
10	−8	N.W.	First arrival from McDames and Thibert Cr. on ice.
11	12	S.W.	First arrival from head of lake on ice.
12	16	S.W.	Cloudy.
13	18	S.W.	Heavy snow p.m.
14	20	S.W.	" " last night.
15	4	W.	Bright and clear.
16	−4	N.W.	Snow.
17	1	N.W.	Bright and clear.
18	14	S.W.	Cloudy.
19	24	S.	Very mild, bright and clear.
20	20	S.	Heavy thaw; lake open in places.
21	12	W.	Cloudy.
22	6	W.	"
23	−2	N.W.	Bright and clear.
24	−4	N.W.	" " "
25	−8	N.W.	" " "
26	−4	N.W.	" " "
27	−6	N.W.	" " "
28	−7	S.W.	" " "
29	−4	S.W.	" " "
30	−8	N.W.	" " "
31	−10	N.W.	" " "
1879.			
Jan. 1	−4	N.W.	" " "

Date.	Minimum Temperature.	Direction of Wind.	Remarks.
1879.	°		
Jan. 2	—1	S.W.	Bright and clear.
3	4	S.W.	" " "
4	6	S.W.	Bright and clear; light snow last night.
5	10	S.W.	Bright and clear.
6	6	S.W.	" " "
7	0	S.W.	Snowing.
8	8	S.W.	"
9	—22	S.W.	Bright and clear.
10	—26	N.	" " "
11	—32	N.	" " "
12	—36	S.	Snowing: at noon, —12°.
13	—30	S.	Bright and clear.
14	—22	S.	Snowing; at noon, —4°.
15	6	S.	Cloudy.
16	0	S.	Bright and clear.
17	4	S.	" " "
18	—2	N.	Snowing; very stormy.
19	—6	N.	Bright and clear.
20	—4	S.	" " "
21	—6	S.	Cloudy; stormy p.m.
22	—8	N.	Stormy all day.
23	—2	N.	Strong drifting.
24	—18	N.	Bright and clear.
25	—24	S.	" " "
26	—20	S.	Cloudy.
27	—2	S.	Bright and clear.
28	10	S.	Cloudy.
29	12	S.	Bright and clear.
31	12	S.	Bright and clear; snow last night.
Feb. 1	10	S.	Bright and clear.
2	—11	N.	" " "
3	—11	S.	" " "
4	6	S.	Storming.
5	16	S.	Storming; heavy snow last night.
6	10	N.	Bright and clear.
7	—6	N.	" " "
8	—27	N.	" " "
9	—29	S.	" " "
10	—18	N.	" " "
11	—26	S.	" " "
12	—26	S.	" " "
13	—24	S.	" " "
14	—23	S.	" " "
15	—20	S.	" " "
16	—10	N.	" " "
17	—19	N.	" " "
18	—17	N.	Stormy.
19	—20	N.	Bright and clear.
20	—15	N.	Stormy, drifting.
21	—25	N.	Bright and clear.
22	—26	N.	" " "
23	—16	N.	Stormy, drifting.
24	—24	N.	Bright and clear.
25	—30	N.	" " "
26	—10	N.	Snow last night.
27	—10	N.	Heavy storm, snowing, drifting.
28	—8	N.	Snowing and drifting.
Mar. 1	—6	N.	Heavy wind, drifting.
2	4	N.	Storming.
3	0	N.	"
4	—12	N.	Bright and clear.
5	—23	N.	" " "
6	—12	R.	Cloudy, drifting.
7	6	N.	Bright and clear.
8	—6	N.	" " "
9	—4	N.	Bright and clear; strong wind.
10	—18	N.	Bright and clear.
11	—16	S.E.	" " "
12	—20	N.	" " "

Date.	Minimum Temperature.	Direction of Wind.	Remarks.
1879.	°		
Mar.13	—20	N.	Bright and clear.
14	4	N.W.	Stormy.
15	—9	N.	Bright and clear.
16	—19	N.	" " "
17	2	N.	" " "
18	—4	N.	" " "
19	2	S.	" " "
20	10	N.	" " "
21	2	.....	" " "
22	10	N.W.	" " "
23	2	N.W.	" " "
24	0	N.	Storming.
25	18	N.W.	Very mild.
26	22	N.	Strong wind.
27	22	N.	Snowing.
28	24	.....	
29	.....	.....	
30	14	.....	Bright and clear.
31	1	.....	
•	•	•	• • • •
Nov.18	2	N.	Snowing and drifting all day.
19	4	N.	drifting, cloudy.
20	12	N.	Light snowfall.
21	14	N.	Cloudy; clear towards evening.
22	4	N.	Cloudy.
23	14	S.	"
24	12	S.	Cloudy; north wind in evening.
25	3	N.	Mild: lake partially frozen over.
26	12	S.	Light snow; lake frozen over.
27	14	.....	Cloudy; light snow.
28	—12	N.	Bright and clear.
29	—20	N.	" " "
30	—28	N.	" " "
Dec. 1	—30	N.	Cloudy; strong wind.
2	—22	N.	Storming.
3	—21	N.	"
4	—10	N.	Cloudy.
5	—10	N.	Bright and clear.
6	—10	N.	Cloudy.
7	—33	N.	Bright and clear.
8	—31	N.	Bright and clear; high wind.
9	—31	N.	Cloudy and storming; strong wind.
10	—30	N.	Cloudy and storming; strong wind.
11	—22	N.	Cloudy and storming; strong wind.
12	—14	N.	Cloudy and storming; strong wind.
13	—24	N.	Cloudy and storming; strong wind.
14	—12	N.	Cloudy and storming; strong wind.
15	—4	N.	Cloudy and storming; strong wind.
16	—26	N.	Bright and clear; strong wind.
17	—37	S.	Cloudy.
18	—28	N.	Bright and clear.
19	—32	N.	Cloudy.
20	—22	N.	Bright and clear.
21	—28	N.	" " "
22	—32	N.	" " "
23	—22	N.	" " "
24	10	N.	Cloudy; light snowstorm.
25	8	N.	Bright and clear.
26	—18	N.	" " "
27	—42	S.	" " "

Date.	Minimum Temperature.	Direction of Wind.	Remarks.
1879.	°		
Dec. 28	—38	N.	Bright and clear.
29	—11	N	Cloudy.
30	—3	N.	"
31	—5	N.	Snowing and drifting.
1880.			
Jan. 1	—18	N	Bright and clear.
2	—27	N.	" " "
3	—33	N.	Cloudy, drifting.
4	—22	N.	" "
5	—29	N.	Bright and clear; at noon —30°.
6	—45	N.	Bright and Clear.
7	—43	N.	Cloudy.
8	—43	N.	Bright and clear.
9	—45	N.	" " "
10	—44	N.	" " "
11	—45	N.	" " "
12	—44	N.	" " "
13	—40	N.	" " "
14	—30	N.	" " "
15	—28	N.	Storming and drifting.
16	—25	N.	" " "
17	—41	N.	Bright and clear.
18	—26	N	Cloudy.
19	—10	S.	Cloudy; light wind.
20	8	S.	Bright and clear.
21	4	S.	Cloudy; light snow in p.m.
22	0	S.	Bright and clear; heavy S. gale last night.
23	—12	S.	Bright and clear.
24	—10	N.	" " "
25	—30	N.	" " "
26	—40	N.	" " "
27	—43	N.	" " "
28	—14	S.	Light snow; 8 a.m., 0°.
29	—4	S.	Cloudy.
30	12	S.	"
31	14	S.	"
Feb. 1	16	S.	Bright and clear; light snow last night.
2	10	S.	Cloudy.
3	24	S.	Very soft.
4	0	S.	Very soft; at noon, 12°.
5	4	S.	Very soft.
6	—14	N.	Bright and clear.
7	—22	......	" " "
8	8	S.	Cloudy.
9	2	......	Bright and clear.
10	—16	......	" " "
11	—12	......	
12	0	N.	Cloudy; S. wind p.m.
13	—12	S.	Cloudy.
14	—14	N.	Bright and clear.
15	—14	N.	" " "
16	—38	N.	
17	—12	N.	Cloudy; light snowfall.
18	—12	N.	Bright and clear.
19	......	......	Heavy snowstorm.
20	12	S.	Storming all day; heavy snows last night.
21	12	S.	Heavy snowstorm last night.
22	18	......	
23	—8	......	Bright and clear.
24	......	......	
25	......	......	Bright and clear; high wind.
26	—42	N.	Bright and clear.
27	—16	N.	Cloudy, mild.
28	4	S.	Light wind.
29	0	N.	Bright and clear.
Mar. 1	—34	N.	Bright and clear; 4 p.m., —7°.
1880.	°		
Mar. 2	—39	N.	Bright and clear; 4 p.m., —2°.
3	—34	N.	Strong wind; bright and clear; 4 p.m., —8°.
4	—32	N.	Strong wind; bright and clear; 4 p.m., 12°.
5	—34	N.	Bright and clear; 4 p.m., —16°.
6	—44	N.	Bright and clear; 4 p.m., —12°.
7	—22	N.	Bright and clear; 4 p.m., 2°.
8	—12	S.	Storming all day; 30° above zero.
9	14	S.	Cloudy; strong wind last night.
10	8	N.	Bright and clear; strong wind.
11	—27	......	Bright and clear.
Nov. 1	......	......	Mild; light snowfall.
2	......	N.W.	" " "
3	......	N.W.	Mild.
4	......	S.	Very mild; raining.
5	......	S.	Very mild; heavy rain.
6	......	S.	Heavy fall of snow.
7	......	S.	Very mild.
8	12	N.	Mild, cloudy.
9	0	N.	" "
10	0	N.	" "
11	12	N.	Mild; raining in evening.
12	......	S.	Mild; rain.
13	......	S.	Mild.
14	......	S.	Mild; summer weather.
15	26	N.	Frosty, beautiful morning
16	14	N.	Cloudy; fine weather.
17	14	N.	Clear and bright.
18	14	N.	" " "
19	8	N.	Cloudy; light snowfall.
20	11	N.	" " "
21	22	S.	Cloudy.
22	18	N.	Cloudy and mild.
23	13	N.	" " "
24	7	S.	Cloudy and mild; snowing in evening.
25	15	S.	
26	13	S.	Cloudy.
27	15	S.	Bright and clear.
28	10	S.	Cloudy; lake partially frozen.
29	18	S.	High winds; ice broken up.
30	21	N.	Strong wind.
Dec. 1	4	N.	Bright and clear; high wind.
2	—14	N.	Cloudy; lake partially frozen.
3	—15	N.	Cloudy; light snow; lake frozen over.
4	—6	N.	Cloudy; high wind.
5	—10	N.	Bright and clear; crossed lake on ice.
6	—20	N.	Bright and clear; strong wind.
7	—19	N.	Cloudy; strong wind.
8	—14	N.	Cloudy; drifting; light snow.
9	—13	N.	Storming and drifting.
10	—2	S.	
11	12	S.	
12	5	S.	Light snow.
13	4	S.	
14	15	S.	
15	—8	N.	
16	—14	N.	Cloudy; drifting.

Date.	Minimum Temperature.	Direction of Wind.	Remarks.
1880.	°		
Dec. 17	—15	N.	Bright and clear.
18	—12	N.	Bright and clear; south wind p.m.
19	—11	N.	Bright and clear; 8 p.m., —20°.
20	—23	N.	Bright and clear.
21	—18	N.	" " "
22	—21	N.	" " "
23	—21	N.	Cloudy.
24	—13	N.	Bright and clear.
25	—14	N.	" " "
26	—21	N.	Bright and clear; very heavy wind.
27	—21	N.	Bright and clear; very heavy wind.
28	—22	N.	Bright and clear; very heavy wind.
29	—16	N.	Cloudy.
30	—10	N.	Bright and clear.
31	6	S.	Light snowfall.
1881.			
Jan. 1	14	S.	
2	16	S.	
3	14	S.	Light snowfall.
4	4	S	" "
5	5	N.	Light snowfall; cloudy.
6	6	N.	" "
7	4	S.	" "
8	9	S.	Bright and clear.
9	4	S.	Cloudy; snowfall last night.
10	—2	N.	Windy; drifting.
11	—17	N.	Bright and clear.
12	—24	N.	Bright and clear; 5 p.m., —25°.
13	—29	N.	Cloudy.
14	—28	N.	Bright and clear.
15	—20	S.	Cloudy; noon, 0°.
16	2	S.	Cloudy.
17	2	S.	Bright and clear.
18	2	S.	" " "
19	15	S.	Cloudy; light snow.
20	2	S.	Cloudy.
21	10	S.	Bright and clear.
22	20	S.	Cloudy.
23	10	S.	Bright and clear.
24	0	S.	" " "
25	—20	N.	" " "
26	—17	S.	Cloudy.
27	—1	N.	Bright and clear.
28	—28	N.	" " "
29	—39	N.	" " "
30	—34	S.	Cloudy.
31	—10	N.	Cloudy; light snow; drifting.
Feb. 1	—2	N.	Snowing and drifting.
2	—22	N.	Cloudy.
3	—14	N.	Snowing and drifting; heavy storm.
4	—19	N.	Bright and clear.
5	—14	N.	" " "
6	—10	N.	" " "
7	—14	S.	" " "
8	—18	N.	" " "
9	—12	N.	" " "
10	—12	N.	" " "
11	—11	N.	Cloudy.
12	—0	N.	Cloudy; clear p.m.
13	—8	N.	Bright and clear; windy.
14	—30	N.	Bright and clear.
15	—25	S.	Cloudy.
16	4	S.	Cloudy and light snow.
17	4	S.	Light snow.
18	6	N.	Light snow; drifting.

Date.	Minimum Temperature.	Direction of Wind.	Remarks.
1881.	°		
Feb. 19	—1	N.	Heavy snow-storm; drifting.
20	—29	N.	Bright and clear.
21	—37	N.	" " "
22	—37	N.	Cloudy; drifting.
23	—4	N.	Heavy snowfall.
24	—15	N.	Bright and clear.
25	—37	N.	" " "
26	—38	N.	" " "
27	—6	N.	Cloudy.
28	—6	N.	Cloudy and drifting.
Mar. 1	—5	N.	Bright and clear.
2	0	S.	" " "
3	6	S.	Cloudy; light snow.
4	6	S.	Cloudy.
5	4	S.	Cloudy; snowfall p.m.
6	16	S.	Cloudy.
7	4	N.	"
8	2	N.	Cloudy; snow storm p.m.
9	2	N.	Cloudy; high wind.
10	0	S.	Bright and calm; light snow in evening.
11	8	S.	Light snow.
12	6	N.	" "
13	—18	S.	Cloudy.
14	18	N.	Cloudy; light snow.
15	17	S.	Cloudy.
15	12	N.	"
17	7	N.	Snow-storm; drifting.
18	6	N.	Cloudy.
19	12	S.	Light snow; heavy thaw.
20	24	S.	Spring weather.
21	24	S.	
22	26	S.	
23	—2	S.	
24	8	S.	Bright and clear.
25	—6	S.	" " "
26	0	S.	" " "
27	above zero.	S.	Cloudy; light snow.
28	"	S.	Snow-storm; drifting; strong wind.
29	"	N.	Snowstorm; drifting; strong wind.
30	"	N.	Rain in evening.
31	"	N.	
May 25	......	......	Creek commenced to rise.
30	......	......	Highest water.
June 4	......	......	First trip of steamer to Thibert Creek. *Very cold, wet summer.*
Sep. 27	......	......	Snowfall in evening.
Oct. 6	......	......	Light snowfall.
21	......	......	" "
22	......	......	Rain.
23	......	......	"
26	......	......	Very mild.
Nov. 1	26	S.	Light snow.
2	26	S.	Heavy rain last night.
3	31	S.	Snow all gone.
4	25	N.	Very light snow.
5	25	N.	" " "
6	23	S.	" " "
7	23	S.	" " "
8	29	S.	" " "
6	30	S.	Strong wind.
10	23	S.	
11	18	S.	Heavy snow; storming all day.
12	8	N.	Heavy winds.
13	3	N.	Heavy winds; drifting.
14	—5	N.	Bright and clear.
15	—15	N.	" " "
16	—20	N.	Cloudy; at noon, —4°.

Date.	Minimum Temperature.	Direction of Wind.	Remarks.
1881.	°		
Nov. 17	—4	N.	Lake partially frozen over.
18	20	S.	Heavy snowfall.
19	12	N.	
20	21	S.	Light snow.
21	6	N.	Bright and clear.
22	3	N.	Lake frozen opp. town.
23	10	S.	
24	23	S.	At noon, 34°.
25	26	S.	At noon, 38°; rain.
26	34	S.	Raining.
27	13	S.	Bright and clear; Indian crossed ice.
28	18	S.	Snowstorm.
29	18	N.	Bright and clear.
30	2	N.	Cloudy: lake nearly all frozen.
Dec. 1	16	S.	Ice broken up between town and Thibert Cr.
2	13	S.	Strong wind.
3	3	S.	Cloudy.
4	3	S.	Bright and clear.
5	0	S.	Light snowfall.
6	1	S	Bright and clear.
7	5	S.	Heavy fog in morn.; p.m. clear.
8	—9	S.	Heavy fog in morn.; p.m. clear.
9	—0	S.	Light snow, drifting.
10	—14	S.	Bright and clear.
11	—23	S.	“ “ “
12	—41	S.	“ “ “
13	—25	N.	“ “ “
14	—20	N.	Cloudy.
15	—20	N.	Light snowfall.
16	—15	S.	Light snowfall; drifting.
17	7	S.	Bright and clear.
18	5	S.	“ “ “
19	22	S.	Heavy wind; drifting; heavy snow-storm.
20	8	S.	Bright and clear.
21	—7	N.	Cloudy.
22	—6	N.	Bright and clear.
23	—3	N.	Cloudy.
24	10	N.	
25	25	S.	
26	28	S.	
27	—5	N.	Bright and clear.
28	—10	N.	“ “ “
29	—5	N.	“ “ “
30	—10	N.	Cloudy.
31	—10	N.	Heavy snow-storm; drifting.
1882.			
Jan. 1	—15	N.	Cloudy.
2	—23	N.	Bright and clear.
3	—14	N.	“ “ “
4	—17	N.	“ “ “
5	—20	N.	Cloudy.
6	—11	S.	Cloudy; light snow.
7	—4	S.	Cloudy.
8	1	S.	“
9	6	S.	Light snowfall.
10	—11	N.	Bright and clear.
1	—8	N.	Cloudy; light snowfall.
12	5	S.	Beautiful morning, like spring.
13	25	S.	Bright and clear; heavy rain last night.
14	—17	N.	Bright and clear.
15	—21	N.	Cloudy; light snow.
16	29	S.	Heavy rain, turning to snow.
17	25	S.	Heavy rain; light snow.

Date.	Minimum Temperature.	Direction of Wind.	Remarks.
1882.	°		
Jan. 18	7	S.	Cloudy; snowfall.
19	20	S.	Cloudy, snowfall; rain in evening.
20	—1[illegible]	N.	Cloudy; snowfall.
21	—13	N.	Cloudy.
22	—15	N.	Bright and clear.
23	—29	S.	“ “ “
24	—13	N.	Drifting.
25	—16	N.	Bright and clear.
26	—47	N.	“ “ “
27	—47	S.	Cloudy.
28	—20	S.	“
29	15	S.	Strong wind.
30	10	S.	
31	5	S.	Strong wind; drifting.
Feb. 1	3	S.	Bright and clear.
2	—1	S.	“ “ “
3	6	S.	Cloudy.
4	6	S.	Bright and clear.
5	—4	S.	Drifting.
6	—3	S.	“
7	—12	N.W.	Very heavy drifting and snowing.
8	—13	N.	Drifting.
9	—25	N.	Bright and clear.
10	—20	N.	Cloudy; drifting.
11	—42	N.	Cloudy.
12	—20	N.	Light snow.
13	—10	N.	Heavy snow, drifting.
14	—14	N.	Storm.
15	—41	N.	Bright and clear.
16	—52	N.	“ “ “
17	—26	S.	“ “ “
18	—21	S.	Cloudy; weather changed.
19	—11	S.	Strong wind.
20	1	S.	Cloudy.
21	28	S.	Cloudy; strong wind.
22	12	S.	Cloudy.
23	—26	N.	Bright and clear.
24	—14	N.	Cloudy.
25	—3	N.	“
26	—11	N.	Very strong wind; drifting.
27	—15	N.	Heavy wind; drifting.
28	—6	N.	Cloudy.
Mar. 1	—4	N.	Storming.
2	—26	N.	Bright and clear.
3	—31	N.	“ “ “
4	—32	N.	“ “ “
5	—25	S.	Cloudy.
6	4	S.	Bright and clear.
7	9	S.	Very fine.
8	13	S.	“ “
9	—18	S.	Bright and clear.
10	—14	S.	Very fine.
11	0	S.	Rain in evening.
12	15	N.	Cold wind.
13	2	N.	
14	—3	N.	Bright and clear.
15	—26	N.	“ “ “
16	—4	N.	High wind.
17	—22	N	Very cold wind.
18	—29	N.	Bright and clear; strong wind.
19	—33	N.	Bright and clear.
2	—34	N.	Drifting; cold wind.
21	—16	N.	“ “ “
22	—40	N.	Bright and clear.
23	—8	N.	Heavy storm; snowing and drifting.
24	5	N	Heavy fall of snow.
25	14	N	Storming; snow.
26	8	N.	Cloudy.
27	10	N.	Heavy snowfall all day.

Date.	Minimum Temperature.	Direction of Wind.	Remarks.	Date.	Minimum Temperature.	Direction of Wind.	Remarks.
1882.	°			1882.	°		
Mar. 28	—17	N.	Bright and clear.	Apr. 12	—2	S.	Cloudy; cold wind.
29	—39	N.	" " "	13	—5	......	" " "
30	—39	N.	" " "	14	14	S.	" " "
31	—20	N.	High wind; drifting.	15	23	S.	" " "
April 1	2	N.	Cloudy; drifting.	16	27	S.	" " "
2	2	N.	Cloudy.	17	20	S.	Snowing and storming.
3	5	N.	High wind: drifting.	18	20	S.	Snowing in evening.
4	11	N.	Cloudy.	19	23	N.	Cloudy; cold wind.
5	11	N.	"	20	7	S.	Cloudy; storming in eve.
6	14	N.	Light snowfall all day.	21	22	W.	Storming; cold wind.
7	12	N.	Fine day.	22	24	S.	Bright and clear.
8	15	N	Raw, cold wind.	23	2	S.	Cloudy; light snow drifting.
9	12	N.	Cloudy.			N.	
10	20	S.	Bright and clear.	24	7		Bright and clear.
11	—1	S.	Cloudy; cold wind.			S.	

(4.) RECORD OF TEMPERATURE AT LAKETON, DEASE LAKE, B. C., DURING PORTIONS OF THE YEARS 1886 AND 1887, BY MR. ROBERT REED.

Date.	Minimum Temperature.	Date	Minimum Temperature.	Date.	Minimum Temperature.	Date.	Minimum Temperature.
1886.	°	1886.	°	1887.	°	1887.	°
Nov. 20	—14	Dec. 22	—30	Jan. 23	—30	Feb. 26	—40
21	—21	23	—44	24	—28	27	—30
22	—11	24	—38	25	—34	28	—31
23	—14	25	—39	26	—29	Mar. 1	—55
24	—2	26	—41	27	—40	2	—49
25	—4	27	—40	28	—61	3	—13
26	—3	28	—34	29	—61	4	—9
27	Stormy.	29	—43	30	—52	5	—15
	19	30	—36	31	—52	6	—45
28	16	31	—35	Feb. 1	—42	7	—32
29	14			2	—47	8	—28
30	7	1887.		3	—56	9	—15
Dec. 1	6	Jan. 1	—32	4	—48	10	—41
2	—4	2	—25	5	—37	11	—31
3	—7	3	—13	6	—38	12	—22
4	7	4	—13	7	—25	13	—12
5	13	5	—10	8	—31	14	—13
6	12	6	—23	9	—49	15	—7
7	12	7	8	10	—27	16	—10
8	3	8	10	11	—23	17	—5
9	—2	9	11	12	—3	18	—12
10	3	10	—5	13	—31	19	2
11	—1	11	—6	14	—32	20	2
12	—5	12	8	15	—1	21	18
13	1	13	—7	16	—14	22	25
14	—2	14	—28	17	—33	23	2
15	7	15	—35	18	—2	24	—20
16	—9	16	—54	19	—21	25	—9
17	Lake frozen.	17	—32	20	—32	26	—2
	—18	18	—27	21	—35	27	8
18	—16	19	—23	22	—5	28	11
19	—10	20	—29	23	—23		
20	—8	21	—46	24	—43		
21	—6	22	—39	25	—45		

APPENDIX VII.

SUMMARY OF ASTRONOMICAL OBSERVATIONS BY DR. G. M. DAWSON, EMPLOYED IN THE CONSTRUCTION OF THE MAP ACCOMPANYING THIS REPORT.

NOTE.—The angular instrument employed was a sextant of seven inch radius, Cary, No. 938. The longitudes of places on the map depend on two small chronometers, Frodsham, No. 06859, and Arnold, No. 9699, running mean and sidereal time respectively. The first-mentioned was employed in taking time in all the observations, and has been given double weight in longitude determinations beyond Telegraph Creek, as it was an instrument of higher class than No. 9699, and proved to be extremely trustworthy. The chronometers were rated wherever possible, as shown in the annexed note. No. 9699 changed its rate suddenly on one occasion, in consequence apparently of a slight jar received on Finlayson Lake, but subsequently recovered a satisfactory rate. The longitude of the site of Fort Selkirk on the map depends entirely on that brought round by our route from Wrangell, as we are still in possession of the preliminary plotting only, of Mr. Ogilvie's Lewes River traverse. (See foot note on p. 276 B.)

The chronometers, in their cases, were packed together in a padded leather-covered box, which was invariably handled and transported with the greatest care. Comparisons were made throughout the journey on every second day at 8 P.M., approximate local mean time.

General Note on Rates of Chronometers, determined at Esquimalt, Dease Lake, Frances Lake and Camp near site of Fort Selkirk.

Frodsham, No. 06859, running mean time.

Rate determined on board H. M. S. *Triumph*, at Esquimalt, May 4-9	·2	seconds	daily,	losing.
Dease Lake, June 5-7 by obsn	·37	"	"	"
Frances Lake, July 11-16 by obsn	·48	"	"	"
Camp near site of Fort Selkirk, Aug. 13-17, by obsn	·625	"	"	"

Arnold, No. 9699, running sidereal time. Rate given on mean time, and including the daily difference between sideral and mean time (=3 m. 56.555 s.)

Rate determined on board H.M.S. *Triumph*, at Esquimalt, May 4-9....	3′ 53″·45	seconds daily, losing.
Dease Lake, June 5-7, by obsn.......	3′ 54″·078	" " "
Frances Lake, July 11-16, by obsn....	3′ 54″·82	" " "
Camp near site of Fort Selkirk, Aug. 13-17, by obsn....................	3′ 52″·6	" " "

(Chronometer received a slight shock since last determination of rate, which accounts for its sudden change.)

Wrangell, Alaska, May 19, 1887.

	h.	m.	s.				
Frodsham, 06859.....	1	12	51·5	Obs. alt. $\overline{\odot}$.....	88°	5′	20″
	1	15	03·5		88	34	30
	1	17	24.5		89	5	10
	1	18	12·5		89	15	30
	.1	20	0		89	38	30
	1	21	42·5		90	1	30
	1	23	20·5		90	21	55
Index error and eccentricity............................						—2	9

Taking latitude of observation spot as 56° 28′ 18″, from U. S. Pacific Coast Pilot, Alaska, Part I, 1883.

Chron. 06859 fast .... 3h. 49m. 03s.

River-bank near site of H. B. Co.'s old post, Stikine R., May 21, 1887.

	h.	m.	s.				
Frodsham, 06859.....	1	5	17	Obs. alt. $\overline{\odot}$.....	86°	57′	35″
	1	7	16		87	24	10
	1	8	26		87	38	50
	1	9	44		87	56	20
	1	10	41		88	8	30
Index error and eccentricity............................						—2	31
Chron. 06859 fast					3h.	46m.	33·4s.

	h.	m.	s.			
Frodsham, 06859.....	3	48	28·5	106°	48′	0″
	3	50	10·5	106	46	40
	3	51	15	106	45	10
Index error and eccentricity					—1	52·5
Resulting latitude from above two series of observations..				57	8	1
Longitude by Frodsham, 06859..........................				131	46	45

Glenora, Stikine River, May 23, 1887.

Jupiter, obs. merid. alt....................................	46°	4′	5″
Index error and eccentricity..........................		—3	49
∴ Latitude	57	50	16

Telegraph Creek, Stikine River, May 27, 1887.

Jupiter, obs. merid. alt....................................	46°	7′	25″
Index error and eccentricity..........................		—3	44
∴ Latitude..	57	55	0

Telegraph Creek, May 28, 1887.

	h.	m.	s.				
Frodsham, 06859.....	12	27	16·5	Obs. alt. $\overline{\overline{\odot}}$.....	79°	55′	0″
	12	28	21·5		80	10	40
	12	29	49		80	31	40
	12	31	29		80	55	30
Index error and eccentricity........................						—2	48
∴ Frodsham, 06859, fast.....					3h.	44m.	06·1s.

Telegraph Creek, May 29, 1887.

	h.	m.	s.				
Frodsham, 06859.....	2	0	22	Obs. alt. $\overline{\overline{\odot}}$.....	99°	25′	0″
	2	2	28·5		99	45	10
	2	4	3		100	0	0
	2	6	12		100	20	0
	2	8	23		100	40	10
Index error and eccentricity........................						—2	39
∴ Frodsham, 06859, fast.....					3h.	44m.	04·5.s.

Telegraph Creek, May 29, 1887.

Obs. meridian alt. $\overline{\overline{\odot}}$..................................	108°	5′	50″
Index error and eccentricity........................		—2	23
∴ Latitude	57	54	56

Telegraph Creek, May 29, 1887.

	h.	m.	s.				
Frodsham, 06859.....	5	25	39	Obs. alt. $\overline{\odot}$.....	99°	0′	50″
	5	26	37		98	41	10
	5	27	51		98	28	50
	5	29	32·5		98	11	55
	5	30	44·5		97	59	20
Index error and eccentricity........................						—2	42
∴ Frodsham, 06859, fast..................................					3h.	44m.	07·2s.

Telegraph Creek, May 30, 1887.

	h.	m.	s.				
Frodsham, 06859.....	6	37	51·5	Obs. alt. $\overline{\overline{\odot}}$.....	84°	34′	50″
	6	39	51·5		84	6	30
	6	41	26		83	44	55
	6	43	3·5		83°	22′	10″
	6	45	2·5		82	54	0
Index and eccentricity................................						—2	42
∴ Frodsham, 06859, fast					3.h.	43m.	56·4s.

Telegraph Creek, Stikine River (summary):

Diff. in long. between Fort Wrangell and Telegraph Creek, by comparing two a.m. sets of observations :

Frodsham, 06859	1°	13′	40″
∴ Chron. long. of Telegraph Creek	131	10	20
Latitude adopted	57	55	58

NOTE.—By Hunter's surveyed line, continued by that of McConnell to Telegraph Creek, the longitude, depending on observation point at Wrangell, (long. 132° 24′ 00″) is 131° 10′ 05″. As the chronometers were subjected to exceptional conditions while ascending the Stikine by steamer, this longitude is adopted for Telegraph Creek in preference to that resulting from observations.

Head of Dease Lake, June 5, 1887.

	h.	m.	s.				
Frodsham, 06859	6	32	22	Obs. alt. ☉	85°	45′	40″
	6	33	44		85	27	0
	6	34	55·5		85	11	0
	6	36	2·5		84	55	20
	6	37	23		84	37	5
	6	38	30		84	21	50
Index error and eccentricity						—2	53
∴ Frodsham, 06859, fast					3h.	39m.	18.5s.

Head of Dease Lake, June 5, 1887.

	h.	m.	s.				
Frodsham, 06859	3	29	34	Obs. alt. ☉	108°	57′	15″
	3	30	38		108	58	10
	3	31	59		108	58	40
	3	33	45·5		109	0	20
	3	34	56		109	0	55
	3	36	8		109	1	5
	3	37	27		109	1	25
	3	38	21·5		109	1	30
	3	39	25·5		109	1	15
	3	41	11		109	0	35
	3	42	53		108	59	10
	3	44	14		108	58	30
	3	45	52		108	57	35
	3	47	14		108	56	40
Index error and eccentricity						—2	2
∴ Latitude					58	28	17·3

Head of Dease Lake, June 7, 1887.

Obs. merid. alt. ☉	109°	13′	15″
Index error and eccentricity		—2	1·5
∴ Latitude	58	28	6

	h.	m.	s.				
Frodsham, 06859	6	56	34	Obs. alt. ☉	80°	33′	30″
	6	57	47		80	15	20
	6	58	38·5		80	2	50
	6	59	40		79	48	10
	7	0	40		79	33	25
Index error and eccentricity						—2	50
∴ Frodsham, 06859, fast					3h.	39m.	17·8s.

Head of Dease Lake (summary).

Diff. in long. between Telegraph Creek and head of Dease Lake:

Frodsham, 06859	1° 10′ 34″·5
Arnold, 9699	1 9 54·5
Adopted diff.	1 10 20

NOTE.—Here, and subsequently throughout, double value is assigned to Frodsham, 06859.

∴ Chron. long. of head of Dease Lake .... =130° 0′ 00″

NOTE.—This longitude depends directly on Wrangell by chronometers. Taking into consideration the corrected longitude for Telegraph Creek, and assuming a mean value as between chronometer longitude and longitude by paced traverse from Telegraph Creek to head of Dease Lake, the longitude of head of lake is found to be 130° 2′ 0″, which is adopted. Subsequent longitudes along the line of traverse are made to depend fundamently on this position.

Adopted latitude, from series of circum-meridian altitudes, June 5, 1887, 58° 28′ 17″·3.

Laketon, Dease Lake, June 17, 1887.

	h.	m.	s.				
Frodsham, 06859	1	18	2	Obs. alt. ☉̿	93°	55′	5″
	1	21	33		94	37	0
	1	23	35		95	1	30
	1	25	44		95	26	30
	1	29	5·5		96	5	20
	1	30	2		96	16	0
	1	31	56		96	37	45
Index error and eccentricity						—2	19
∴ Frodsham, 06859, fast					3h. 39m. 26s.		

	h.	m.	s.				
Frodsham, 06859	3	42	31·5	Obs. alt. ☉̿	109°	57′	30″
	3	43	51		109	57	0
	3	45	16·5		109	56	20
	3	46	47		109	55	35
Index error and eccentricity						—1	50

	h.	m.	s.				
Frodsham, 06859	8	14	20·75	Obs. alt. ☉̿	62°	24′	50″
	8	16	10·5		61	56	40
	8	17	16·5		61	39	5
	8	19	2·75		61	12	0
	8	20	1·5		60	56	50
	8	21	1·3		60	36	0
Index error and eccentricity						—3	9
Resulting adopted lat. from second and third series of observations					58	42	20

By last observation:

Frodsham, 06859, fast	3h. 39m. 16s.
Diff. in long. between Laketon and head of lake by long bearings	3′ 32″
∴ Resulting adopted long. of Laketon	130° 5′ 32″

Sta. I, Dease River, June 19, 1887.

Obs. merid. alt. $\overset{=}{\odot}$	109°	34′	15″
Index error and eccentricity		—2	3
∴ Latitude	58	56	38·9

Sta. U, Dease River, June 20, 1887.

Obs. merid. alt. $\overset{=}{\odot}$	109°	13′	50″
Index error and eccentricity		—2	03
∴ Latitude	50	7	25·6

Sta. E, Dease River, June 21, 1887.

Obs. merid. alt. $\overset{=}{\odot}$	108°	49′	45″
Index error and eccentricity		—2	0
∴ Latitude	59	19	35·2

Sta. M, June 22, 1887.

	h.	m.	s.				
Frodsham, 06859	10	17	13	Obs. alt. $\overset{=}{\odot}$	50°	38′	40″
	10	19	17		51	0	50
	10	20	18		51	26	0
	10	21	2·25		51	37	0
Index error and eccentricity						—3	1
∴ Frodsham, 06859, fast					3h.	36m.	16s.
Lat. for above observation from traverse					59°	34′	0″
Diff. in long. between place and head of Dease Lake, Frodsham, 06859						44	0
∴ Chron. long. of place					129	18	0

Sta. U 2, Dease River, June 22, 1887.

Obs. merid. alt. $\overset{=}{\odot}$	108°	4′	15″
Index error and eccentricity		1	57·3
∴ Latitude	59	42	5·8

Lower Post, mouth of Dease River, June 25, 1887.

	h.	m.	s.				
Frodsham, 06859	1	21	35	Obs. alt. $\overset{=}{\odot}$	93°	55′	25″
	1	22	46		94	8	0
	1	23	25·5		94	15	35
	1	24	8		94	23	50
	1	25	37		94	40	5
	1	26	41·5		94	51	30
	1	27	22		94	58	30
	1	28	6		95	6	20
	1	29	2		95	16	20
Index error and eccentricity						—2	16·5
∴ Frodsham, 06859, fast					3h.	32m.	0·8s.

NOTE.—This series of observations was not employed in determining long., the sun being too near meridian.

	h.	m.	s.				
Frodsham, 06859.....	3	19	34	Obs. alt. $\overline{\overline{\odot}}$.....	107°	17′	20″
	3	20	24		107	18	50
	3	21	24		107	20	40
	3	22	44·5		107	22	5
Index error and eccentricity						—1	51

By a.m. obsn. and last, with interval of time.

Latitude	59	55	56·7

	h.	m.	s.				
Frodsham, 06859.....	3	37	31	Obs. alt. $\overline{\overline{\odot}}$.....	107°	30′	10″
	3	38	30		107	29	20
Index error and eccentricity						—1	51

By a.m. obsn., and this, with interval of time.

Latitude	59	55	55

Difference in long. between place and head of Dease Lake:

Frodsham, 06859	1°	32′	24″	
Arnold, 9699	1	30	40·5	
Mean, (giving double value to Frodsham)	1	31	50	
∴ Chron. long. of place	128	30	10	
Long. ascertained by bearings carried through by Dease River	128	35	10	adopted

Sta. I, Cañon on Upper Liard River, June 26, 1887.

Obs. merid. alt. $\overline{\overline{\odot}}$	107°	16′	20″
Index error and eccentricity		—1	58
∴ Latitude	60	1	6·2

Sta. P, Upper Liard River, June 27, 1887.

Obs. merid. alt. $\overline{\overline{\odot}}$	107°	6′	30″
Index error and eccentricity		—1	58·5
∴ Latitude	60	3	43·7

Sta. Y, Upper Liard River (confluence of Frances R.), June 29, 1887.

Obs. merid. alt. $\overline{\overline{\odot}}$	106°	29′	10″
Index error and eccentricity		—2	19·5
∴ Latitude	60	16	35·3

Sta. F, Frances River, June 30, 1887.

	h.	m.	s.				
Frodsham, 06859.....	9	10	54	Obs. alt. $\overline{\overline{\odot}}$.....	47°	30′	25″
	9	11	49·5		47	17	10
	9	12	38·5		47	5	15
	9	13	25·5		46	53	45
	9	14	12·5		46	41	50
	9	15	1·5		46	30	0
	9	16	21		46	10	50
Index error and eccentricity						—3	19
∴ Frodsham, 06859, fast					3h.	35m.	38·8s.
Lat. for above obsn. by traverse					60°	26′	0″
∴ Long. by Frodsham, 06859					129	11	46

Sta. H, Frances River, July 1, 1887.

	h.	m.	s.		°	′	″
Frodsham, 06859.....	3	42	45·5	Obs. alt. $\bar{\bar{\odot}}$.....	105°	53′	0″
	3	44	9·5		105	52	30
	3	45	23·5		105	52	10
	3	46	12·5		105	51	20
Index error and eccentricity..............................						—2	0
With time by last observation and long. of traverse,							
Latitude...					60	27	28

Sta. W, Frances River, July 3, 1887.

Obs. merid. alt. $\odot$..	105°	10′	45″
Index error and eccentricity................................		—2	0
.·. Latitude..	60	39	15·1

NOTE.—Observation fair only.

Sta. E, Frances River, July 4, 1887.

Obs. merid. alt. $\bar{\bar{\odot}}$..	104°	41′	50″
Index error and eccentricity................................		—2	15·5
.·. Latitude..	60	47	53·4

Sta. P, Frances River, July 7, 1887.

Obs. merid. alt. $\bar{\bar{\odot}}$..	103°	24′	35″
Index error eccentricity................................		—2	18
.·. Latitude..	61	9	25

Câche Camp, Frances Lake, near mouth of Finlayson River, July 11, 1887.

	h.	m.	s.		°	′	″
Frodsham, 06859.....	12	45	32	Obs. alt. $\bar{\bar{\odot}}$.....	81°	15′	30″
	12	46	41		81	28	50
	12	48	23		81	49	20
	12	49	15		82	0	0
	12	50	55		82	20	0
	12	52	36		82	40	0
	12	54	18		83	0	0
	12	56	1		83	20	0
Index error and eccentricity..............................						—3	17
.·. Frodsham, 06859, fast..............................					3h.	37m.	23s·9.

Câche Camp, Frances Lake, July 7, 1887.

	h.	m.	s.		°	′	″
Frodsham, 06859.....	3	35	33·5	Obs. alt. $\bar{\bar{\odot}}$.....	101°	43′	40″
	3	36	32		101	44	25
	3	37	19		101	44	50
	3	38	16·5		101	45	0
	3	39	26		101	45	20
	3	40	24·5		101	45	40
	Approx. app. noon				101	45	50
	3	43	20		101	45	30
	3	45	26		101	45	10

h.	m.	s.				
3	46	36·5		101	45	5
3	47	58		101	44	30
3	49	1·5		101	44	0
3	50	53		101	42	40

Index error and eccentricity		—2	38
∴ Latitude	61	29	22

Câche Camp, Frances Lake, July 11, 1887.

	h.	m.	s.				
Frodsham, 06859	6	29	1·5	Obs. alt. ☉̿	83°	20′	0″
	6	30	44		83	0	0
	6	22	23		82	40	0
	6	34	7·5		82	20	0
	6	35	45		82	0	0
	6	38	20		81	28	50
Index error and eccentricity						—3	16
∴ Frodsham, 06859, fast					3h.	37m.	29s.

Câche Camp, Frances Lake, July 16, 1887.

	h.	m.	s.				
Frodsham, 06859	10	55	18	Obs. alt. ☉	55°	5′	50″
	10	56	18·5		55	20	45
	10	57	35		55	38	30
	10	58	31·5		55	52	10
	10	59	11		56	2	35
	11	0	6		56	14	45
	11	1	31		56	34	30
Index error and eccentricity						—3	40
∴ Frodsham, 06859, fast					3h.	37m.	22s.

Diff. in long. between place and head of Dease L. by mean of two first obsns.

Frodsham, 06859	0°	23′	36″
Arnold, 9699	0	21	22·5
Mean. (giving double value to Frodsham)	0	22	51·5
∴ Chron. long. of place	129	39	8·5 adopted.

Sta. P, Frances Lake, July 12, 1887.

Obs. merid. alt. ☉̲	101°	46′	30″
Index error and eccentricity		—2	34
∴ Latitude	61	21	7·9

Sta. T, Finlayson Lake, July 24, 1887.

Obs. merid. alt. ☉̲	96°	53′	30″
Index error and eccentricity		—2	37·6
∴ Latitude	61	40	12·9

Correction for temp. and pressure,—6.″

St. U, Finlayson Lake, 14″ south of last, July 24, 1887.

	h.	m.	s.				
Frodsham, 06859	9	43	48	Obs. alt. ☉̿	36°	0′	35″
	9	44	47		35	46	25
	9	45	40		35	34	0

h.	m.	s.				
9	46	37		35	20	50
9	47	37·5		35	8	20
9	48	20		34	56	30
9	49	0		34	47	10

Index error and eccentricity .... —3 34

∴ Frodsham, 06859, fast .... 3h. 40m. 29s.

St. V, Finlayson Lake, July 25, 1887.

	h.	m.	s.				
Frodsham, 06859.....	12	51	45	Obs. alt. ☉.....	77°	0′	0″
	12	52	47·5		77	12	5
	12	53	36·5		77	21	50
	12	54	25·5		77	31	0
	12	55	25		77	42	40
	12	56	13		77	52	10
	12	57	6·5		78	2	30
	12	57	47		78	10	25
	12	58	45		78	21	10

Index error and eccentricity .... —3 23

∴ Frodsham, 06859, fast .... 3h. 40m. 46s.

Obs. merid. alt. ☉ .... 96° 28′ 10″

Index error and eccentricity .... —2 38

Correction for temp. and pressure, —6.

∴ Latitude .... 61 40 0·6

Sta. V, Finlayson Lake (summary).

Mean of last obsn. and that of July 24, reduced to this point, gives,

Latitude .... 61° 40′ 0″ adopted.

Diff. in long. between place and Câche Camp, Frances Lake:

Frodsham, 06859..........		50′	12″	
Arnold, 9699..........		46	51	
Mean, (giving double value to Frodsham)..		49	5	
∴ Chron. long. of place	130°	28′	13″.5	
Long. of place by traverse between Frances Lake and Pelly Banks..........	130	28	52	
Mean of this and chron. long..........	130	28	32·7	adopted.

Pelly River, First Camp, near site of Fort Pelly Banks, July 29, 1887.

	h.	m.	s.				
Frodsham, 06859.....	7	4	59	Obs. alt. ☉.....	70°	54′	30″
	7	6	46		70	32	35
	7	7	41·5		70	20	50
	7	8	33.5		70	10	0
	7	9	23		69	59	10
	7	10	14·5		69	48	30
	7	12	17		69	23	10
	7	13	15		69	11	10
	7	13	58		69	2	10

Index error and eccentricity .... —3 22

∴ Frodsham, 06859, fast .... 3h. 42m. 45s.

Pelly River, First Camp, July 29, 1887.

	h.	m.	s.				
Frodsham, 06859.....	7	57	32·5	Obs. alt. $\overline{\odot}$.....	59°	1′	40″
	7	58	58·5		58	42	0
	7	59	46·5		58	31	10
	8	1	11		58	12	0
	8	2	19		57	55	50
	8	3	17		57	43	10
	8	3	58		57	33	30
Index error and eccentricity						—3	30
∴ Frodsham, 06359, fast					3h. 42m. 46s.		

Pelly River, First Camp, July 31, 1887.

	h.	m.	s.				
Frodsham, 06859.....	12	36	49	Obs. alt. $\overline{\odot}$.....	70°	54′	0″
	12	37	53		71	7	0
	12	38	56·5		71	19	30
	12	39	46		71	30	0
	12	40	31·5		71	38	40
	12	41	28		71	50	40
	12	42	31		72	2	55
	12	43	25·5		72	14	0
	12	44	23		72	25	20
Index error and eccentricity						—3	21
∴ Frodsham, 06859, fast					3h. 43m. 42s·9		
Obs. approx. merid. alt. $\overline{\odot}$					93°	23′	10″
Index error and eccentricity						—2	42
∴ Latitude					61	48	59

	h.	m.	s.				
Frodsham, 06859.....	3	54	7·5	Obs. alt. $\overline{\odot}$.....	93°	21′	50″
	3	55	12		93	21	20
	3	56	34		93	20	40
	3	57	50		93	19	15
Index error and eccentricity						—2	42″·5

	h.	m.	s.				
Frodsham, 06859.....	7	45	57.5	Obs. alt. $\overline{\odot}$.....	61°	11′	40″
	7	47	1		60	57	5
	7	48	19·5		60	39	10
	7	49	10·5		60	27	55
	7	50	8·5		60	15	10
	7	50	45·5		60	6	45
	7	51	25·5		59	57	50
	7	52	7·5		59	48	5
	7	53	5·5		59	35	30
Index error and eccentricity						—3	29
∴ Frodsham, 06859, fast				3h. 42m. 45s·8			

Pelly River, First Camp (summary).

By last two obsns., with interval of time:

Latitude.................................... 61° 48′ 52″ adopted.

Diff. in long. between Câche Camp, Frances L. and place by mean of sets of obsns.

Frodsham, 06859	1	22	7·5	
Arnold, 9699	1	21	39	
Mean, (giving double value to Frodsham) ..	1	21	58	
∴ Chron. long. of place	131	1	6·5	adopted.

Sta. X, Pelly River, Aug. 2, 1887.

Obs. merid. alt. $\bar{\odot}$ (fair only)	92°	30′	20″
Index error and eccentricity		—2	44
∴ Latitude	61	44	52·5

Sta. G, Pelly River (Head of Hoole Cañon), Aug. 3, 1887.

Obs. merid. alt. $\bar{\bar{\odot}}$	91°	48′	0″
Index error and eccentricity		—2	41·5
∴ Latitude	61	50	28

Sta. H, Pelly River (lower end Hoole Cañon), Aug. 4, 1887.

	h.	m.	s.				
Frodsham, 06859	9	49	41·5	Obs. alt. $\bar{\bar{\odot}}$	30°	17′	50″
	9	50	31		30	30	0
	9	51	26·5		30	42	30
	9	53	8		31	5	40
	9	54	41·5		31	27	25
	9	55	35		31	40	10
	9	56	26		31	52	10

Index error and eccentricity		—3	25
∴ Frodsham, 06859, fast	3h.	46m.	47s·5

NOTE.—For above obsn., lat. employed determined by paced line from Sta. G. .... 61° 50′ 48″·8

Long. by chronometers (giving double value to Frodsham) 132° 1′ 51″

Sta. B, Pelly River, Aug. 5, 1887.

Obs. merid. alt. $\bar{\bar{\odot}}$	90°	4′	5″
Index error and eccentricity		—2	45
∴ Latitude	62	10	20

Sta. L, Pelly River, Aug. 6, 1887.

Obs. merid. alt. $\bar{\odot}$ (passing clouds, approx.)	89°	2′	15″
Index error and eccentricity		—2	54
∴ Latitude	62	24	53

Sta. C, Pelly River, Aug. 7, 1887.

Obs. merid. alt. $\bar{\bar{\odot}}$	87°	57′	10″
Index error and eccentricity		—2	54
∴ Latitude	62	40	41

Sta. N, Pelly River, Aug. 8, 1887.

Obs. merid. alt. $\bar{\odot}$	87°	12′	10″
Index error and eccentricity		—2	41
∴ Latitude	62	46	4

Sta. T, Pelly River (6 m. above Macmillan River), Aug. 8, 1887.

Frodsham, 06859.....	9	31	23·5	Obs. alt. $\bar{\odot}$.....	37°	8′	10″
	9	32	21·5		36	55	10
	9	33	25		36	40	50
	9	34	18·5		36	28	20
	9	35	7·5		36	17	10
	9	35	59		36	5	30
	9	36	39		35	56	0
	9	37	34·5		35	44	0
	9	38	9		35	36	0
Index error and eccentricity..................................						—3	19
∴ Frodsham, 06859, fast					4h.	1m.	29s.
NOTE.—For above obsn. lat. employed determined by traverse					62°	48′	10″
Long. by chronometers (giving double value to Frodsham)					135	44	25·5

Sta. O, Pelly River, Aug. 10, 1887.

Obs. merid. alt. $\bar{\bar{\odot}}$ (approx.).......................................	85°	52′	25″
Index error and eccentricity.......................................		—2	58
∴ Latitude..	62	51	10

Observations near site of Fort Selkirk.

Three-quarters of a mile below Fort Selkirk, Aug. 11, 1887.

	h.	m.	s.				
Frodsham, 06859.....	4	1	8·5	Obs. alt. $\bar{\odot}$.....	85°	19′	0″
	4	2	0		85	19	40
	4	2	52		85	20	20
	4	3	58		85	21	10
	4	5	28		85	22	5
	4	7	3		85	22	55
	4	8	15·5		85	23	30
	4	13	17		85	24	25
	4	14	43		85	23	50
	4	16	47·5		85	23	35
	4	17	45·5		85	23	0
	4	18	38·5		85	22	40
	4	19	43		85	22	20
	4	20	50		85	21	35
	4	21	45		85	20	55
Index error and eccentricity..................................						—3	4
Correction for temp. and pressure, —6.″							
∴ Latitude					62	47	32

Camp opposite Fort Selkirk, Aug. 11, 1887.

	h.	m.	s.				
Frodsham, 06859.....	8	12	7·5	Obs. alt. $\bar{\odot}$.....	54°	37′	30″
	8	13	16·75		54	22	30
	8	14	2·5		54	12	40
	8	14	53·5		54	1	50
	8	15	30		53	54	5
	8	16	36		53	39	10

	h.	m.	s.				
	8	17	35·5		53	27	0
	8	18	16		53	18	0
	8	18	58·5		53	9	10
Index error and eccentricity..........................						—2	39
∴ Frodsham, 06859, fast					4h. 7m. 42s·3		

Camp opposite Fort Selkirk, Aug. 12, 1887.

	h.	m.	s.				
Frodsham, 06859....	7	35	59·5	Obs. alt. $\bar{\bar{\odot}}$.....	61°	30′	50″
	7	38	18		61	2	30
	7	39	22·5		60	50	20
	7	40	10·5		60	40	10
	7	40	58·5		60	30	55
	7	42	5		60	17	30
	7	43	20·5		60	2	10
Index error and eccentricity..........................						—2	35
∴ Frodsham, 06859, fast					4h. 7m. 46·5s		

Camp opposite Fort Selkirk, Aug. 13, 1887.

	h.	m.	s.				
Frodsham, 06859.....	0	58	46·5	Obs. alt. $\bar{\bar{\odot}}$... .	63°	0′	0″
	1	1	22		63	30	0
	1	3	8·5		63	50	0
	1	4	52·5		64	10	0
	1	7	33·5		64	40	0

	h.	m.	s.				
Frodsham, 06859.....	4	4	10·5	Obs. alt. $\bar{\bar{\odot}}$.....	84°	6′	55″
	4	5	33		84	7	35
	4	7	57		84	8	15
	4	9	7		84	8	25
	4	10	4·5		84	8	40
	4	10	59·5		84	9	10
	4	12	44		84	9	0
	4	13	32·5		84	8	50
	4	14	39		84	8	40
	4	16	35		84	8	10
	4	17	46		84	7	40
	4	18	44		84	7	25
Index error and eccentricity..........................						—3	7
Correction for temp. and pressure, —6·7							
∴ Latitude.............................					62	47	32·4

	h.	m.	s.				
Frodsham, 06859.....	7	16	30·5	Obs. alt. $\bar{\bar{\odot}}$.....	64°	40′	0″
	7	19	9·5		64	10	0
	7	20	54		63	50	0
	7	22	40		63	30	0
	7	25	16·5		63	0	0

By the above series of observations, paired with a.m. series by equal altitudes, Frodsham, 06859, fast............ 4h. 7m. 47·5s

Camp opposite Fort Selkirk, Aug. 15, 1887.

	h.	m.	s.				
Frodsham, 06859.....	1	17	56·5	Obs. alt. ☉.....	65°	30′	0″
	1	19	48·5		65	50	0
	1	21	41·5		66	10	0
	1	23	32·5		66	30	0
	1	25	25·5		66	50	0
	1	27	20·5		67	10	0

	h.	m.	s.				
Frodsham, 06859.....	6	55	55	Obs. alt. ☉.....	67°	10′	0″
	6	57	48·5		66	50	0
	6	59	42·5		66	30	0
	7	1	37		66	10	0
	7	3	29·5		65	50	0
	7	5	19		65	30	0

By the above sets of equal alt. obsns. Frodsham, 06859, fast 4h. 7m. 46·5s

Camp opposite Fort Selkirk, Aug. 17, 1887.

	h.	m.	s.				
Frodsham, 06859.....	0	39	16·5	Obs. alt. ☉.....	57°	0′	0″
	0	40	55·5		57	20	0
	0	42	35		57	40	0
	0	44	16		58	0	0
	0	45	56·75		58	20	0

	h.	m.	s.				
Frodsham, 06859.....	4	7	38	Obs. alt. ☉.....	81°	36′	40″
	4	9	10		81	37	10
	4	11	5		81	37	20
	4	12	0·5		81	37	5
	4	13	29		81	36	30
	4	16	30		81	35	55
	4	17	32·5		81	35	20
Index error and eccentricity..........................						—2	0
Correction for temp. and pressure, —5·3							
∴ Latitude					62	47	29

	h.	m.	s.				
Frodsham, 06859.....	7	36	25	Obs. alt. ☉.....	58°	20′	0″
	7	38	5		58	0	0
	7	39	46		57	40	0
	7	41	26		57	20	0
	7	43	7		57	0	0

By the above series of observations, paired with a.m. series by equal altitudes, Frodsham, 06859, fast .... 4h. 7m. 45s.

Camp opposite Fort Selkirk, Aug. 17, 1887.

Obs. merid. alt. Altair..................................	71°	35′	30″
Index error and eccentricity*.........................		+1	8
Correction for temp. and pressure, —4·1			
Latitude	62	47	28·3

* The adjustments of the sextant were changed here.

Site of Fort Selkirk (summary).

Reducing the foregoing latitude observations (taken at two different points) to the ruins of Fort Selkirk, we find:—

From obs. of 11th	62°	47′	12″	adopted.
" " " 13th	62	47	12·4	
" " " 17th	62	47	9	
" " " 17th (on Altair)	62	47	8·3	

Diff. in long. between Câche Camp, Frances L. and Camp opp. Fort Selkirk, by directly comparing two equal alt. obsns.:—

Frodsham, 06859	7°	40′	9″	
Arnold, 9699	7	42	34·5	
Mean, (giving double value to Frodsham)	7	40	57·5	adopted.
∴ Long. of Camp opposite Fort Selkirk	137	20	6	
Or reduced to site of Fort Selkirk	137	20	22 *	

Lower end Lake Labarge, Sept. 4, 1887.

	h.	m.	s.				
Frodsham, 06859	12	20	54	Obs. alt. Arcturus	48°	58′	30″
	12	23	29		48	21	30
	12	25	35		47	51	40
	12	27	18		47	26	20
	12	28	38·5		47	7	30
	12	30	14·25		46	44	30
Index error and eccentricity						+1	2
∴ Frodsham, 06859, fast					3h.	58m.	46s.
∴ Long. of place					135°	5′	45″

	h.	m.	s.				
Frodsham, 06859	12	36	22	Obs. alt. Polaris	122°	46′	10″
	12	39	7		122	47	55
	12	41	11		122	49	20
	12	43	35		122	50	55
	12	45	44		122	52	30
	12	47	38		122	53	35
	12	49	57		122	55	25
Index error and eccentricity						+2	56
∴ Latitude					61	25	13

Employing local time obtained from observations on Arcturus.

	h.	m.	s.				
Frodsham, 06859	1	2	1	Obs. alt. Altair	74°	20′	10″
	1	4	28		74	18	25

* The longitude thus determined for Fort Selkirk, depends directly upon Wrangell, and my line of traverse by the Stikine, Dease, Liard, Frances and Upper Pelly rivers. It is that used on the accompanying map. Since the map has been engraved, and after this Appendix was in type, a first computation (still subject to possible small corrections) has been made of Mr. Ogilvie's winter observations near the 141st meridian and of his instrumental traverse from Fort Selkirk to that point. His resulting longitude for Fort Selkirk is 137° 22′ 45″, the difference between the two independently determined positions being 2216 yards only. It is therefore probable that all intermediate places on my line of traverse are correct in longitude within small limits of error.

	1	5	52·5	74	17	40
	1	7	21·5	74	16	20
	1	8	59	74	15	10
	1	10	59	74	13	10
Index error and eccentricity..............................					+1	20
∴ Latitude..				61	25	0

Employing local time obtained from observations on Arcturus.

Observations for Magnetic Variation.

Mag. variation observed at head of Dease Lake.
Lat. 58° 28′ 17″·3. Long. 130° 2′ 0″

June 5, 1887, 3.40 p.m., obs. var. E........................ 30° 26′ 0″

Mag. variation observed at Frances Lake.
Lat. 61° 29′ 22″. Long. 129° 39′ 8″·5.

Date and time.	True bearing of object.	Mag. bearing.	Obs. variation.	
July 12, '87, 6 a.m....	127° 37′	93° 45′ compass 1	33° 52′	mean 33° 45′·5
" " " " " ..	127° 37′	93° 0′ compass 2	33° 47′	

Mag. variation observed at First Camp on Pelly River.
Lat. 61° 48′ 52″. Long. 131° 1′ 6″·5.

Date and time.	True bearing of object.	Mag. bearing.	Obs. variation.	
July 30, '87, 5.40 p.m.	202° 59′	167° 45′ compass 2	34° 24′	mean 34° 30′
" " " " "	202° 59′	168° 45′ compass 3	34° 36′	
" " " 6.40 p.m.	308° 18′	273° 30′ compass 2	34° 0′	

Mag. variation observed opposite site of Fort Selkirk.
Lat. 62° 47′ 30″. Long. 137° 20′ 6″.

Date and time.	True bearing of object.	Mag. bearing.	Obs. variation.
Aug. 12, '87, 4 p.m......	169° 27′	134° 15′ compass 2	35° 12′*
" " " " "	169° 27′	135° 30′ compass 3	34° 0′*

Determined by Mr. Ogilvie at same place (with transit).... 34° 21′·5
" " " " " " " at Fort Selkirk... 34° 5′

* The differences between these obsns. and Mr. Ogilvie's at same place, were assumed as index error of instruments and applied to the obsns. at other places.

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA.
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR.

REPORT

ON THE GEOLOGY OF THE

MINING DISTRICT OF CARIBOO,

BRITISH COLUMBIA,

BY

AMOS BOWMAN, M.E.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

MONTREAL:
DAWSON BROTHERS.
1888.

To Alfred R. C. Selwyn, Esq., C.M.G., F.R.S., LL.D.,

Director Geological and Natural History Survey of Canada.

Sir,—The first part of my report on the mining district of Cariboo, British Columbia, is herewith respectfully submitted. The second portion will include details and detailed plans of mining developments.

I have the honor to be, Sir,

Your obedient servant,

AMOS BOWMAN.

NOTE.—The bearings throughout this report are given with reference to the true meridian, unless otherwise specially noted.

REPORT

ON THE GEOLOGY OF THE

MINING DISTRICT OF CARIBOO, BRITISH COLUMBIA.

BY AMOS BOWMAN, M.E.

PART I.

The work in the Cariboo District of British Columbia, here reported upon, was carried out during the seasons of 1885 and 1886, under the control of the Director of the Geological Survey, but with the assistance of a money grant from the Government of British Columbia, and on a plan agreed upon beforehand. The enlightened policy of the Government of British Columbia has thus rendered possible the completion of the map work in a comparatively short space of time, the demands upon the funds of the Geological Survey being such as to make it impossible to devote more than a certain sum annually to work in each province or district. The call for special assistance in the Cariboo district arose principally from the absence of any trustworthy map, and the necessity of undertaking a geographical as well as a geological survey, while the decline in product of the placer mines, and the efforts being made toward the development of "quartz mining" appeared to deserve such immediate assistance and guidance as might be afforded by a systematic study of the district and a reasonably accurate delineation of its features. Joint, Provincial and Dominion surveys.

Cariboo has not only been the mainstay of gold mining in British Columbia for many years, but has proved, for its area, one of the richest placer mining camps in the world; and it would therefore appear reasonable to assume the existence in it of rich quartz lodes, from which, by natural processes of waste, the alluvial deposits have been supplied. The importance of the Cariboo district will be understood when it is stated that probably half the gold product of British Columbia since 1860, or not less than $15,000,000, was derived from it, and chiefly from a few miles in length of auriferous drift in several valleys, of which those of Williams, Lightning and Antler creeks have been the most productive, and have made Cariboo famous. Importance of Cariboo gold fields.

LIMITS OF FIELD.

On plateau region of the Upper Fraser.

Politically, Cariboo district embraces a complete section across the northern interior plateau, from the coast mountains to the Rocky Mountain region, north of the Canadian Pacific Railway, and within the drainage basin of the Fraser. This is bisected in a north and south line by Fraser River. Popularly, "Cariboo" includes only the eastern half, or the gold country north of Lake La Hache. To the principal mining developments of this area our investigations were accordingly confined, and the map herewith presented does not include all the outlying portions even of the area thus limited.

The south-eastern limits of the Cariboo mining district include the valley of the Horsefly, and country extending eastward of it to the water-shed of the Clearwater and North Thompson rivers.

The most northerly mines of importance within this area are those of Hixon Creek, a tributary of Cañon Creek, between Quesnel and Fort George; and the newly-discovered mines of Goat River, a tributary of the Upper Fraser (probably identical with "Shuswap River" on Trutch's map), on the eastern slope of the Cariboo Range.

The lower half of it has been explored by prospectors, and has become tolerably well known by report, to many of the residents of the district beyond present mining localities.

The eastern Alpine region, and the low-lying northern parts, where Bear and Willow rivers join the Fraser, are little known even to the residents of Cariboo, and may be set down as scarcely explored, economically or otherwise. Geographical explorations in these little-known regions have been confined to the lines of survey on the Upper Fraser and Clearwater rivers, by the Government railway parties in 1872–76.

Between the Upper Fraser (Tête Jaune Cache) and the well-known Cariboo mining country of Harvey and Cunningham creeks, the distance is but 50 miles; yet very few prospectors or explorers besides Mahood, of the railway exploration party in 1872, and Isaacs' prospecting party in 1886, have been through it.*

* The best map in existence, which included Cariboo, was that known as Trutch's Map, drawn by J. B. Launders in the Lands and Works Department of British Columbia, under the direction of the Hon. J. W. Trutch, scale 25 miles to the inch; a creditable and well-executed compilation of the surveys of the Admiralty, and surveys and explorations of the Royal Engineer corps under Col. Moody, and above all of the geographical information collected by the Hudson Bay Company's officials from Indians, including the reports of intelligent prospectors and miners, a few of whom had been surveyors. A later map on the same scale was that compiled by E. Mohun, C.E., and published under the direction of the late Hon. W. Smythe, adding to Trutch's map such corrections as had been developed by the Dominion Railway surveyors and the explorations of the Geological Survey; none of them, however, in the mining region of Cariboo. The scale however was much too small for our purpose, and the information was mostly sketched.

Work in 1885.

Adjacent to roads and trails.

The work of this season was necessarily for the most part of a geographical and topographical character, the geological and mining problems being assigned a secondary place till the main outlines of the map had been laid. My assistants during the year were Messrs. James McEvoy, B. Ap. Sc., S. P. Tuck, C.E., and L. R. Voligny, C.E.

Barkerville, in the centre of the Cariboo mining district, was, in the first place, connected by an odometer survey along the waggon road with Quesnel; and from Barkerville as a centre traverses were extended by measuring-wheels along the principal roads and trails of the district.

Work in 1886.

Mountain and outlying areas.

During this season I was assisted by Mr. McEvoy. We entered the southern edge of the Cariboo district map near Beaver Lake on the 6th of July, and work was actively prosecuted in the district till the 30th September. The whole time spent in the field this season was four months and a half, but this included time spent in going to and returning from the district, as well as that consumed in making various necessary arrangements. Pack animals were employed in moving from place to place, wherever possible, but some parts of the district could only be reached on foot; and for the purpose of making a micrometer survey of Quesnel Lake and examining its shores, boats were utilized. Some topographical work was included in the operations of this season, but much of my time was devoted to the detailed examination of mines and auriferous creeks.

The results of field work in 1885 and 1886 included eighty-one plotted sheets, forty panoramic topographical sketches, and ninety-seven smaller sketches of the same kind, chiefly intended to show the topography, and relief of the country.

The mountainous, and often almost inaccessible character of portions of the district included in the maps, presented us with many difficult problems in transportation, and in the execution of the work. These were successfully overcome by the ready and efficient co-operation of my assistants and men.

Dr. Hugh Watt, of Barkerville, obligingly undertook the reading of the mercurial station barometer on which the reduction of our observed altitudes depended. To Messrs. John Bowron and W. Stephenson, Provincial Government Agents at Barkerville and Quesnel Forks respectively, we are indebted for innumerable favors; and, in fact, all the residents of the district, including even the Chinese, seemed to take an interest in our work, and to assist us whenever possible.

Country Surveyed.

The profitable gold fields.

Evidently this vast region could not have been adequately explored in one or two seasons, nor during the progress of systematic surveys in the old placer mining region. Directing our attention, therefore, to a narrower area, as distinguished by profitable mining operations,—included within the limits of the Cariboo District map,—the country topographically surveyed lies within the parallels of 52 deg. 45 min., and 53 deg., 45 min., and the meridians of 120 deg., 45 min., and 122 deg., comprising, thus limited, an area of 3,137 square miles. This block extends into the alpine region mentioned, while it covers the whole of the placer mining country which has been found specially noteworthy on account of its yield of gold.

The first step in our work was to enter the larger field first referred to, and to make the necessary reconnaisance surveys, in order to discover the extent of the gold-bearing country, and its relations to the surrounding country, with a view to narrowing the field. The second was to make a systematic geographical and geological survey of the smaller area.

Survey Operations.

Outside work.

While our survey operations were chiefly confined to the smaller area, the road traverse measured from Lake La Hache to Lightning Creek Meadows, at Beaver Pass, belongs to the wider field. A great deal of both geological and general survey work had to be done outside of the limited area, in order to arrive at necessary results in the mining region itself. It includes reconnaissance surveys of all approaches to the mines, by horse trail and by projected railway; of Quesnel River, including its mines, situated between the forks and the mouth; of the Cottonwood River mines (between Cottonwood Bridge and the Hixon Creek trail-crossing); the trail from Quesnel Mouth to Hixon Creek, about forty miles; and a small area of country at the junction of Hixon and Government creeks, the site of important mining operations.

Bases measured.

The geographical work included the measuring with the steel tape of two independent base lines fifty miles apart, situated respectively on Snowshoe Plateau and at Quesnel Mouth.

Areas mapped in detail.

Detailed maps of all the important mining localities were also completed. The geographical foundation (embracing from one to three miles on the paying creeks,) having been procured during the first season of field work, the details and geological features remained to be obtained during the second.

Accuracy.

The accuracy of the creek maps must not be understood to be equal

to that of a transit survey carried out into all these details; nor is that of the Cariboo district map to be understood as including transit intersections to the minor points, many of which were not in sight from the transit stations. The detail maps were based on compass surveys, and, generally, wheel measurements; but parts of them were filled in by track or reconnaissance surveys, where such information could not be procured in any better shape.

Topography.

The topographical details of the District map were plotted from the sketches described. Where immediate intersections could not be had, the objects were located relatively to fixed points, in such detail as the sketches permitted.

Check work.

I deemed it necessary to occupy a number of transit stations outside of the smaller area, for the purpose of connecting our triangulation system in the mining region with a point on Fraser River at Quesnel Mouth. This served as a check of the waggon road survey. Its principal object, however, was to ensure the accuracy of the triangulation system, by the measurement of a second, or check base, in the neighborhood of Quesnel Mouth.

Positions.

Taking our departure in 1886 from Ashcroft, 8·4 miles south south-east from Cache Creek, the position of that place was fixed by Ogilvie's railway traverse, and Klotz's telegraphic and astronomical observations, under the direction of Captain Deville, the same season, as follows:—

Ashcroft siding, latitude 50° 52′ 50″.
" " longitude 121° 16′ 36″.

Longitude by traverse.

From Cache Creek to a point marked by a stake on the north shore of Lake La Hache, near the 125 mile-post, the Lands and Works Department measured a line following the waggon-road nearly, placing the latter point north of Cache Creek 78¼ miles, and west of it 16⅝ miles. The accuracy of this survey, however, Mr. Gore, the Surveyor-General of British Columbia, considers cannot be guaranteed to be closer than 1-10th of a mile in a measured mile, it having been run by compass, and chained by Indians. Assuming it to be in the main correct,—the point so fixed being the nearest fixed point of the Provincial Land Surveys,—we have for its position:—

Stake on Lake La Hache, lat. 52° 00′ 53″.
" " " long. 121° 16′ 35″.

Thence to Barkerville by our own Survey, with prismatic compass and wheel measurement—courses calculated by latitudes and departures—the position of Barkerville was obtained independently of our own and Lieut. Palmer's astronomical observations. The minus or east departures were found to be in excess of the plus or west departures by just six miles, giving us as the longitudde of Barkerville 121° 33′ 24″.

Longitude.

Latitude.

Its latitude by a series of sextant observations taken by myself and Mr. McEvoy in 1885 as 53° 4′.

Independent observations.

This position agrees very closely both in latitude and longtitude with Lieut. H. S. Palmer's determinations from independent observations, so that the position of the central point of the mining region may be considered as satisfactorily established within the limits of accuracy required.

Skeleton map.

Triangulation.—The diagram on the opposite page shows the triangulation framework of the Cariboo District Map, with primary and calculated triangles.

By the old steamer and waggon road route, followed by us into the country in the working season of 1885, Barkerville, the trading centre of the mining region, was reckoned to be distant from Victoria 550 miles.

COMMUNICATIONS.

Distances.

The following table of distances by steamer and waggon road route is compiled from Williams Directory of British Columbia, 1885, p. 243:

FROM VICTORIA TO

	Westminster.	Sumass.	Hope.	Yale.	Lytton.	Spences Bridge.	Cache Creek.	Clinton.	Soda Creek.	Quesnel.	Stanley.	Barkerville.
	Miles.	Mil's.	Mil's.	Mil's.	Mil's.	Miles.	Miles.	Mil's.	Miles.	Mil's.	Mil's.	Miles.
	75	40	41	19	57	23	30	26	132	60	35	12
Total...	75	115	156	175	232	255	285	311	443	503	538	550

By the old Douglas route, used before completion of the waggon road:—

	Clinton.	Soda Creek.	Quesnel.	Stanley.	Barkerville.
FROM LILLOOET TO	*Miles.*	*Miles.*	*Miles.*	*Miles.*	*Miles.*
	47	179	239	274	286

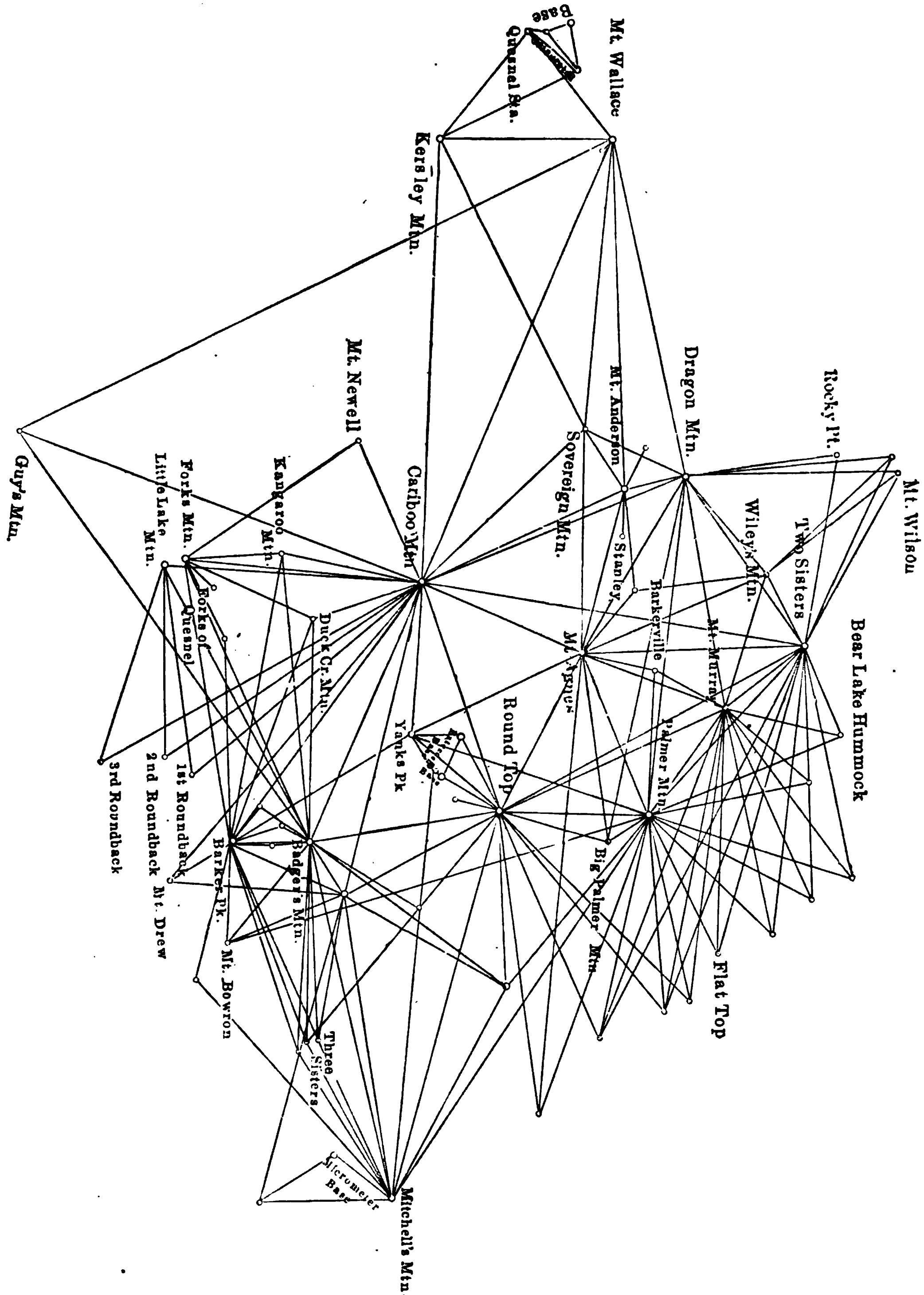


DIAGRAM OF TRIANGULATION POINTS IN CARIBOO DISTRICT.

Road and Trail Distances.

The following is a table of distances obtained with the wheel:—

GOING EASTWARD FROM QUESNEL (H. B. CO'S corner) TO—

	Miles.
Four-mile Creek	3.8
Wallace's Ranche	13.3
Bohannon's, Cottonwood	20.0
Cottonwood Ranche	21.5
Boyd's "Cold Spring House"	25.2
Beaver Pass House	38.3
Stanley Post Office	44.8
Eagle Creek Bridge	47.5
Barkerville	56.5

GOING SOUTH-EAST FROM BARKERVILLE, VIA SAW-MILL FLAT, TO—

	Miles.
Grouse Creek	4.0
Antler Creek Bridge	8.0
Porter's (old Antler Town)	10.5
Littler's cabin, Saw-mill Flat	13.0
Veith's store, Little Snow-shoe	24.4
Junction Little Snow-shoe and Keithley	27.0
Veith & Borland's, mouth of Keithley	32.1
Quesnel Forks	49.0

GOING SOUTH-EAST FROM BARKERVILLE, VIA CUNNINGHAM CREEK, OVER SNOW-SHOE PLATEAU, TO—

	Miles.
Sharp's cabin, Cunningham Creek	16.9
Harvey's Creek Forks	25.3
Veith & Borland's, mouth of Keithley	35.4

GOING NORTH FROM BARKERVILLE TO—

	Miles.
Mosquito Creek	6.2
Cornish Creek	8.4
Hardscrabble Creek	10.5
Walker's mine Sugar Creek	1.5

GEOLOGICAL FIELD WORK.

Method.

During the first season, the method pursued in regard to geological work was simply that of reconnaissance, with a view to observing the accessible features of the district. In places not likely to be revisited, all the necessary geological observations were completed. During the second season, the distribution of the rocks, and the mining features of the country governed, not only my own movements, but largely the movements also of the geographical party, whose work was narrowing towards completion. A section was made from the limestone rocks of

Beaver Lake, through the gold bearing series, to the water-shed of the Cariboo Range between Mitchell's Lake and Canoe River, ending opposite to, and not far distant from Tête Jaune Cache. Subsequently, the chert rocks of Bear River, which occupy a prominent position in Cariboo, were intersected at various points, and in different directions.

Quartz ledges, especially those adjacent to the placer mines, were everywhere noted, and in many instances carefully examined, and sampled for assay.

The most important areas in connection with mining operations within the district, which have been examined in greater detail, are indicated by rectangular blocks, outlined upon the accompanying map. Of these special maps have been drawn, and lithographed on scales, to accompany the descriptive details forming Part II of the present report.

PHYSICAL FEATURES.

Mountains and Valleys.—The relief of the district surveyed is shewn upon the accompanying map by means of contour lines, having a vertical interval of 250 ft.; every fourth one, accordingly, representing 1,000 ft. A heavy contour carried throughout the region represents a datum-plane on a level with the mouth of Williams Creek, near Jack of Clubs Lake, 4,000 ft. above the sea. Each 1,000 ft. contour, is marked by pairs of dots, for easy reference to the datum plane. **Details connected with mining.**

A closer examination of the featurers of the region under consideration, establishes the fact that the north-westerly trends so remarkable for continuity and regularity in the region of the upper Columbia, are here carried out in all the geological and physical details. The Cariboo Range, forming the north-eastern limit of the Cariboo country, is the north-westerly continuation of the Selkirk Range. The crystalline schist or "gold belt," seen on Quesnel Lake, is represented by similar rocks on Shushwap Lake and in Eagle Pass. **Relief.**

The region of Mount Agnes and Snowshoe Plateau is an expanse of smooth and rounded flat-topped schistose hills, having the same uniform north-westerly trend, and rising in Cariboo District to an altitude of a little over 6,000 feet. To the right and left of it, following the same trend, are low-lying valleys forming the present drainage channels of the country. These are occupied by recent deposits. Lying along side of them are ranges of hills occasionally rising into mountains, which represent valleys of an older date, *i. e.* synclinals, or troughs occupied by rocks newer than the gold-bearing series. The valley of Quesnel River on the left or south-west side, is 4,000 feet lower **Mountain axes.**

The gold range. than Snowshoe Plateau; while the valley of Bear River and Bear Lake on the right or north-east side is 3,000 ft. lower than the gold range.

Transverse breaks. Two remarkable breaks cross the schist or gold belt, connecting the two valleys described. These valleys are occupied by streams characteristic of the present drainage system, and by lakes. Cariboo Lake, and Quesnel Lake, extend, or formerly extended, entirely through and across the axis of the gold belt. These lakes, and the low-lying valleys connecting them, are accompained by narrow belts of level land, much of it in the form of terraces or benches. At the lower levels of the country, generally, terraces are frequent. The smooth rounded character of the mountains of the schist belt is, however, itself, due to the presence of these terraces at higher altitudes, and their continuations over the mountain flats and summits, forming plateaus of which Snowshoe Plateau and Bald Mountain Plateau are examples.

Terraces.

On the west, Quesnel River valley becomes a part of the plain. Going eastward, and beyond the axis of the Bear Lake valley, the aspect suddenly becomes alpine.

The reader imagining himself located upon the summit of Mt. Agnes on the map, sees, in the accompaning panoramic sketch looking south-west, that half of the horizon embracing the rolling plains of the interior. Turning around and looking north-west, he sees the gold region at his feet; the alpine region, and other featurers herein described, beyond. By noting the horizontal and vertical angles written along the margins of these sketches, he will be able to identify each point upon the map, or in the country itself.

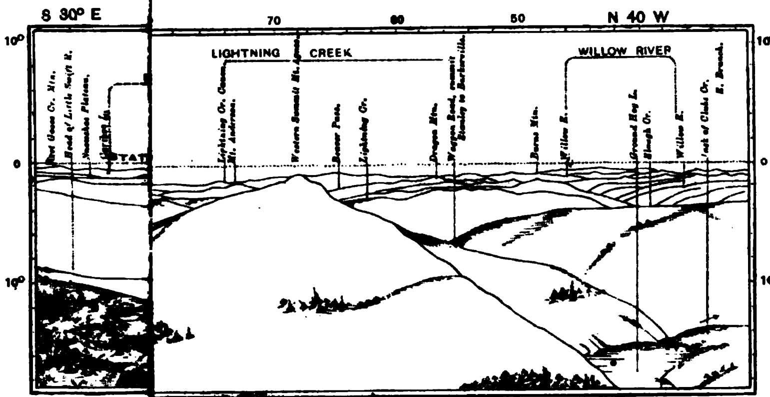
Panoramic views.

From Mt. Barker (six miles east of Cariboo Lake) looking west, he can see the half horizon of another sketch, made to exhibit the character of Snowshoe Plateau, and the cross cutting valley of Cariboo Lake.

Forest. The forest covered portion of the country ceases, going eastward, with the boundary line between the Mesozoic rocks and the gold bearing schists—approximately along a line drawn from the middle of Quesnel Lake to the head of Swift River—and further east generally at altitudes above 3,000 feet.

Thrifty forests exist above that level only in clumps, on sheltered uplands, or on slopes where both soil and shelter are favourable. Such forests and clumps of trees as exist on the higher mountains are often very attractive to the eye, especially on the plateaus of the gold-bearing belt. On the southern slope of Mount Mitchell, in the Cariboo Range, a handsome forest of cedars and firs having an undergrowth of Devil's club, rises to a level of 4,000 feet above the sea.

Snow. Perennial snow lies on the summits of the eastern or Cariboo range, eastward of Bear Lake valley, only between 7,000 and 8,000 feet



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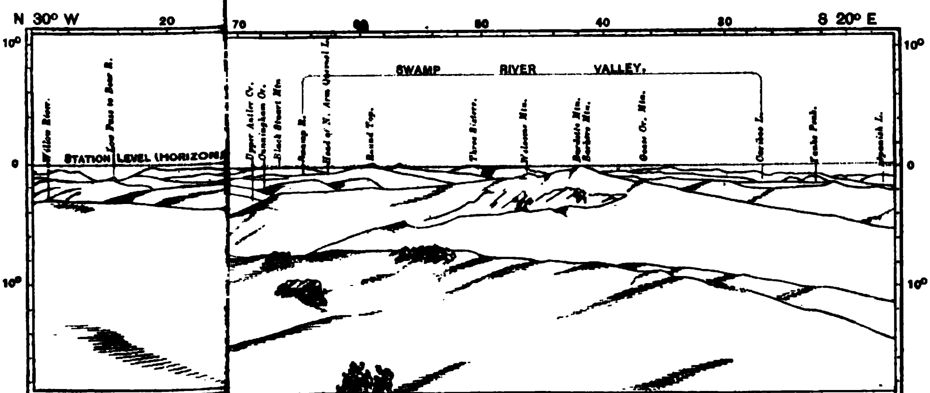

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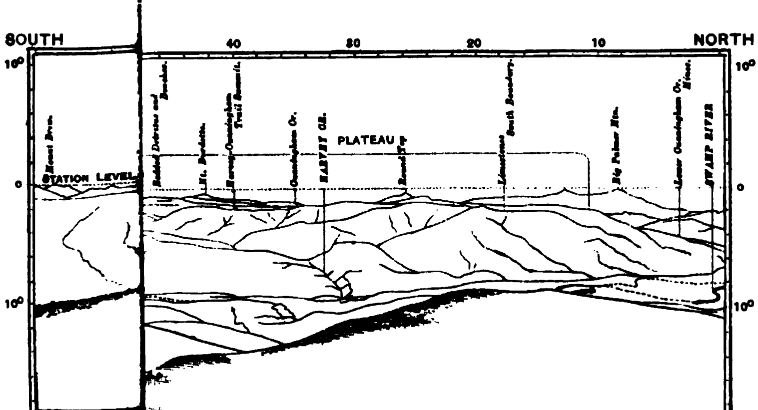

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above the sea. While westward, the surface contour of the country is smooth and pleasing. East of Bear Lake valley all the mountain tops appear rugged, and snow-fields are common and extensive, frequently terminating in glaciers, which descend to a level of 5,000 feet above the sea.

Three-fourths of the territory of the Cariboo map lies above the 3,000 feet contour. Snow lies on the ground above that altitude for four months in the year. Quesnel Lake is closed by ice from November to March.

Geology of Cariboo District.

Approach.

Approaching the Cariboo country from Ashcroft on the Canadian Pacific Railway, the traveller passes over a region, extending from Câche Creek to Clinton, of chert rocks and limestones, which have yielded fossils of Carboniferous age,* and which occupy the plateau in parallel undulations between the Rocky Mountains and the Coast Ranges. Passing over the plateau of the "Green Timber," these undulations are seen to have been completely buried in places by a series of Tertiary clays, sands, and gravels, capped by volcanic matter, and covered by drift of glacial origin and date. Underneath the Tertiary, represented by the gravels and volcanic matter of the Green Timber, are clays and lignites. These have usually been found to be restricted to narrow basins scattered over the plateau of the Cordillera, and have yielded fossils of Miocene age.†

Leaving the waggon-road at the 150-mile house, we reach the south-west corner of the Cariboo Map on Guy's mountain, at 2,500 feet above the sea, being one of the undulations mentioned. It is composed, like many of the Clinton and Hat Creek mountains, of limestone.

Descending from Guy's Mountain into the valley of Beaver Lake, at the low level of 2,200 feet above the sea, we see benches skirting the hill-sides, and beneath the gravels seen in these benches, throughout the region of Cariboo, are found at the lowest levels, occasional croppings of the lignites of the middle Tertiary.‡

Formations observed.

Having thus entered our field of survey at its nearest point to the Canadian Pacific Railway, and Cariboo waggon-road, we are prepared for the transition from the formations heretofore examined, to those now to be described.

*Reports of Dr. Selwyn and James Richardson, 1871-72, pages 56-62; and of Dr. G. M Dawson, 1875-1876-77.

† Reports of Dr. G. M. Dawson for 1875, 1876, and 1877.

‡ The fossils obtained nearest to this locality are from Quensel Mouth, described in Dr. Dawson's Report for 1875-76. The nearest lignite is at Boyd's Cold Spring house, on Lightning Creek, a little above its junction with Swift River, mentioned in the Report of 1876.

Exclusive of the superficial deposits, the rocks met with in the Cariboo district may, according to our present knowledge of them, be classed as follows in descending order:—

Pre-glacial gavels, Pliocene ? Basalts Clay-shales, etc., with lignite, Miocene	Cainozoic.
Quesnel River Beds, argillites, agglomerates, etc. In part at least Lower Cretaceous	Mesozoic.
Bear River Beds, Limestones, cherty quartzites and beds of volcanic materials, probably in part Carboniferous	Palæozoic (Upper.)
Cariboo Schists, rocks more or less completely crystalline, of very varied character	Palæozoic (Lower.)
Quesnel Lake Crystalline Series	Archæan.
Granites and granitoid rocks.	

Recent.

Valley and surface deposits.

The low-lying valleys of Beaver River, Quesnel River, and Bear River, and the higher valley of Willow River, are observed to have flats, which are frequently a mile, to two miles, in width. Still higher lying meadows than those of Willow River, are found in places on nearly all the tributary branches, at various altitudes. Usually these occur where the configuration of the country has led to the formation of basins in the interrupted descent of the streams. The recent deposits of these valleys are indicated by a yellow coloring on the map.

The material of the recent deposits consists of the ordinary thin stratum of humus, or loam, overlying very extensive bodies of sand, and gravel. The latter were washed down from higher deposits of gravel and sediments of an older date, and were bedded in the flats by the present streams.

Soil.

A soil that would be classed as good agricultural land, extends over the low or level portions of the hills and plateaus, yielding excellent crops of grass. Indeed no better grazing country can be found than the mountain meadows of Snowshoe and Bald Mountain plateaus in July, August, and September. These meadows situated at altitudes from 3,000 to 6,000 feet, afford opportunities for summer grazing in in connection with a varied agriculture, and the wintering of cattle at lower levels.

Post Tertiary and Tertiary.

The formations of the Post Tertiary and Tertiary, are unimportant as to area covered, since such areas are usually otherwise colored to represent the underlying rocks. These formations are superficial in character. Where rendered important by their product of gold, and occurring in the form of narrow belts of gravels accompanying the valleys of streams, they are indicated by hachures in red on the map.

But in point of fact the entire surface of the country is covered by Post Tertiary detritus, blending into still older gravels partly Tertiary, of as great or greater economical importance. All these gravels will be appropriately considered and delineated in connection with the details of mining as shown upon the mining maps.

The volcanic rocks of Tertiary age, which are so widely distributed Volcanic.
elsewhere over the plateau of British Columbia, were noted only at two points within the area of the Cariboo map, viz.: on the north arm of Quesnel Lake, (in association with Tertiary gravels), and at Guy's Mountain. In both cases they cover limited areas. The lignite Lignite.
clays, although present, can be seen only in localities situated near the bottom of the lowest valleys, and are usually covered or hidden by the Tertiary and post Tertiary gravels. They represent a notable feature in the drainage of the country related to middle Tertiary history, and will be further referred to in that connection.

Mesozoic.

Quesnel River Beds.

A large area which can be definitely referred to the lower Cretace- Foot hills.
ous, accompanied by an older series of rocks, (which may be Jurassic,) is delineated by a green coloring, occupying the trough of Quesnel River valley. They cover the entire lower and left hand margin of the Cariboo District map.

This belt is crossed in travelling from Beaver Lake to Quesnel Forks, and thence to Kangaroo Creek—along the usual travelled trail from the 150-mile house to the mines. It has an average width of sixteen miles, within the area of the map. All along Quesnel River and at Cedar Creek on lower Quesnel Lake, this formation has yielded auriferous gravels. These were the first "pay gravels" discovered; and the first to be profitably mined in the Cariboo country.

The prevailing habitus of the series is that of mixed volcanic and Volcanic
sedimentary rocks. Massive beds succeed each other with great regu- and sedimentary
larity. The dip is flattish rather than steep, but frequently at a greater rocks.
angle than 45 degrees. Their strike corresponds with the general

trend of the formation, which is that of the troughs and ridges generally.

Boundaries. The limits of the formation are: along Beaver River valley, on their south-west side; and along a line from Upper Swift River to Spanish Lake valley on the north-east side. The latter boundary extends in a north-westerly direction to Lightning Creek, below the Bonanza mine, where it forms Red Cañon of Lightning Creek between the Bonanza and Boyd's Cold Spring house. In the opposite or south-easterly direction, it continues to Quesnel Lake, striking the Lake a few miles above Lynx Peninsula. Thence eastward it forms the south shore of Quesnel Lake.

Aspect. The hills composed of these rocks are much lower than those of the underlying gold bearing schists, on the north-east. Their surface is rough and craggy. Trees appear to have a precarious footing. In a large area on the south-side of Quesnel River the winds and fires together have prostrated most of them before attaining any considerable size. In the valley of Hazeltine Creek, however, the soil derived from this formation is deeper, and the forest is luxuriant. The hills in general have a characteristic even, flattish surface contour. They can be recognized from a distance as belonging to the formation of the trough of Quesnel River valley. Generally they are from two to three thousand feet lower than those of the gold schists.

Localities examined. They were examined at several places on Cottonwood Cañon; between the Cottonwood Ranch and Hixon Creek trail-crossing; at the Donaldson Bridge in the Cañon of the Quesnel ten miles above Quesnel mouth; at Wallace's Mountain, and on the dividing ridge between Quesnel and Cottonwood Rivers; at Morehead Creek; and at several places along the south fork of Quesnel, as well as on the north, and on the shore of Quesnel Lake. Mr. McEvoy noted them along his track-survey from Quesnel Forks to Quesnel Mouth.

Lithological features. There is a lithological resemblance throughout of the rocks of the above named localities, as shown by the specimens collected, which testifies to a history distinct from anything elsewhere observed in the district.

Among them were found the characteristic conglomerates of the "Shasta Group." The cementing material is often a brownish, or greenish mass. From conglomerate to breccia, with the same cementing material, they pass into a compact rock, consisting of the cementing material alone. Sometimes this is crystalline, and in massive beds, less frequently thinly bedded. Of the mineral ingredients aside from hornblende and felspar, the crystalline varieties are frequently fine in grain, and not readily determined without the microscope.

Metamorphism These rocks have been subjected to considerable metamorphism. In small outcrops it is often difficult to recognise any definite strike or

dip, jointage and cleavage planes being more prominent than those of bedding. In the larger exposures the latter can, however, generally be detected.

The bulk of the strata constituting the group are clearly the result of sedimentary deposition, while others are as clearly of contemporaneous volcanic origin, both molten and fragmental.

Fossils were collected on the south shore of Quesnel Lake, near Hazeltine Creek; and at Big Wheel Flat, two miles below the outlet of Quesnel Lake. Of three species collected, two appear to be undescribed. The third is the well-known *Aucella Piochii*, of Gabb, indicating the horizon as probably equivalent to the upper part of the Shasta group of California. Cretaceous.

By reference to the accompanying section, it will be seen that there is a great thickness of these strata overlying some that are auriferous, southward of Quesnel River; and that these latter come to the surface mostly along that stream, and northward of it. Thickness.

Reasons for supposing that Jurassic rocks may be represented in the district, exist in the occurrence of slaty and certain other beds observed immediately below these holding fossils, on the south shore of Quesnel Lake; and in similar slaty beds observed a little above the Falls of the South Fork of Quesnel River, near Quesnel Forks. The latter consist of soft and perfectly black carbonaceous slates of a character also observed in some of the beds in the Cañon of Lightning Creek. These slates differ from those of the older gold schists in possessing no perceptible crystalline ingredients. Jurassic?

The placer mining carried on between the outlet of Quesnel Lake and the town of Quesnel Forks, owes its wealth of gold to the rocks described. If any rocks of Jurassic age occur here they may be supposed to come to the surface unconformably with the Cretaceous. Recent published evidence indicates that the rocks holding *Aucella Piochii*, which have been referred to the Neocomien, may be as new as the Dakota group. Placer mining.

We have here a repetition of gold-bearing rocks exhibiting in several particulars conditions peculiar to the foot-hills of the Sierra Nevada, in California, viz: the occurrence of the Shasta group of Shasta county, with an Aucella allied to that characteristic of the gold-bearing shales in Mariposa county, on which the geological position of the California gold-bearing shales has been based; the association with Carboniferous limestones, in Shasta and Sierra counties, and again, the formation in which these fossils occur flanking a higher range of crystalline schists, containing no fossils, but intimately associated with adjacent older crystalline and granitic rocks, in Cariboo District, as in the Sierra Nevada. Caifornian resemblances.

Upper Palæozoic.

Bear River Limestone and Cherty Series.

Carboniferous.

Allusion has been made to the geological position of the small patch of limestone and associated rocks seen at Guy's Mountain, in the south-west corner of the Cariboo map. This is supposed to be identical with the Carboniferous limestone of Cache Creek and other localities.

Leaving the limestones of Guy's Mountain and the Quesnel River rocks just described, and continuing our route in a north-easterly direction along the line of section marked upon the map—which cuts across these different formations nearly at right angles—we ascend to the plateau of the gold bearing schists, commonly known as the "Slate Belt," near its north-eastern boundary on Round Top Mountain. The usual route of travel is a little to the right of our imaginary line, following the western shore of Cariboo Lake and the valley of Swamp River as far as Harvey Creek, where it ascends Snowshoe Plateau, to our line of section.

Limestones.

Standing on Round Top, and facing north-east, we look across the second geological valley or trough, described as an existing valley, viz., that of Bear Lake, and Upper Swamp River. On Swamp River again, there is an immense white cliff of limestone, in a mountain rising opposite Harvey Creek, a thousand feet above the valley. Similar white cliffs of limestone are seen to the eastward and northward, within a radius of 160 degrees, as far as the eye can reach, for fifty miles, on both sides of the Bear River valley, embracing generally the formation coloured grey upon the map.

Cherts and volcanic rock metamorphism

This formation is remarkable not only for its limestones, but for its cherty rocks, and differs in these respects from any other in the district. Among the chert rocks are occasional beds of volcanic origin, and limestones do not always accompany the cherts. The formation was intersected at many different points, and traversed in many different directions, before its identity and continuity could be ascertained. In contrast with the crystalline schists of the gold belt, none of the characteristic crystalline rocks are to be found init. To this, some of the limestones are an exception. The rocks in general are more compacted and more altered than those of the Mesozoic area of Quesnel River. It forms part of several distinct ranges of mountains; amongst which the Two Sisters (6,800 feet above the sea) are the highest in the vicinity of the gold region, being exceeded in height only by the alpine peaks of the Cariboo Range; the culminating points within the area of this formation averaging about the same height as those of Snowshoe and Bald Mountain plateaus, in the auriferous belt.

On the north-east side, the boundary of the formation is near the western foot of the Cariboo Range, at the lowest levels of the Bear River basin. The south-western boundary is not so distinctly marked by physical featurers. It rises to the same heights, and in many places coalesces with the gold-bearing schists, on the flanks of prominent mountains of its own, or of schist formation.

From Swamp River, at a point a few miles above the junction of Harvey Creek, the line between it and the gold schists crosses over the northern slope of Round Top, and continues thence westward to the Great Bend of Cunningham Creek without having given rise to any decided bounding valleys of erosion. From the last mentioned point continuing westward, it keeps close to, without precisely following, another north-westerly trending chain of valleys, represented by the Cunningham-Antler Pass Creek, a tributary of Cunningham Creek, and by a portion of Antler Creek, Pleasant Valley Creek, Sugar Creek, Valley Creek and Willow River. Boundaries.

It is thirteen miles in width opposite Barkerville and above Bear Lake. It widens towards the north-west, and narrows in the opposite direction to five miles and a half at the head of the North Arm of Quesnel Lake. Width.

In appearance the mountains of this formation are generally smooth. On the summits and higher slopes they are bald and grass covered. They show a brown colouring of soil, visible from a distance of many miles. Their outlines show an intimation of rocky ribs, more apparent than in the mountains of the gold bearing schists. At the same time their regularity sets off, and in rounded and graceful curves contrasts with the rugged peaks of the Cariboo range beyond. Their lower slopes and foot-hills are covered, in all favorable places, by dense and luxuriant forest. Aspect.

The rocks of this formation were examined at Wiley's Mountain, at the head of Sugar Creek, at the Two Sisters Mountains, at points along the trail from Barkerville to Bear Lake, at Mount Murray, along lower Antler Creek, on the Palmer Mountains at Antler-Cunningham Pass, and at the head of the North Arm of Quesnel Lake.

The most striking peculiarity of these beds is the prevalence of greenish cherts, and of jaspery silicious rocks. Older volcanic sediments occur in all gradations of fragmentation, from breccia to sandstone and from sandstone to shale. The cementing material is usually of a greenish cast, as are the rocks themselves, when compact. Green cherts and jasper.

The degree of metamorphism has been plainly much greater than in the Mesozoic area, and distinctly less than in the area of the gold schists. The limestones, for example, are only occasionally and locally altered to a perfectly crystalline condition. Pressure has produced

in some instances, that faint appearance of schistosity which is peculiar to the schists. It has nowhere produced the perfectly crystalline characters universal in the schist belt proper.

At Eight-mile Creek Cañon, on the trail from Barkerville to Bear Lake, along with other characteristic rocks of the series, there are grey schists and sandstones more altered than elsewhere seen within the limits of this formation. It was first thought that these were older than the typical cherts of the Bear River series. A tendency towards a crystalline slaty character is apparent in the mineral ingredients, which, nevertheless, show distinctly on their weathered surfaces, their original fragmental character.

The position of these altered rocks is probably low in the series. They may represent transition beds, rather than the underlying gold schists, from which they differ in uniting distinctly fragmental, with some of the characters of the crystalline rocks. Situated in the axis of the Sisters range, the lower strata of which they represent, a local metamorphism under greater pressure, may sufficiently account for their aspect as described. A tendency to silky foliation in the softer shales is a further characteristic.

Regular bedding.

Another feature notable in the rocks of this formation is their regularity of bedding. The rocks are often seen in massive beds, only moderately inclined.

Fossils.

A series of fossils was collected near one of the mining camps on lower Antler Creek, situated about three miles below the junction of Pleasant Valley and Antler creeks. Crinoids are preserved in the limestone, but unfortunately too imperfectly for determination. Their rounded forms afford only presumptive testimony,—along with the stratigraphic and lithologic evidence—of an age not newer than Upper Palæozoic.

Gold.

The placer mines of Lower Antler Creek have derived their gold from rocks of this formation. The yield has been sufficiently good to indicate the presence of the precious metals in their accompanying veins, in quantities that render them worthy of the attention of the prospector.

Lower Palæozoic.

Schists of the Cariboo Gold Belt.

Axial range.

We come next in descending order to the gold schists; a series of crystalline rocks, which are low down in the geological scale.

The gold range of Cariboo, lying between the two troughs described, has an average width of twenty miles, from Swift River on the west,

to the two Valley Creeks on the east;—or from Spanish Lake, nearer the eastern border of the map, to the head of the North Arm of Quesnel Lake.

Boundaries. Its boundaries are: on the south-west side, the north-eastern boundary of the Mesozoic rocks of the Quesnel River series, already described in detail; on the North-eastern side, that of the Palæozoic rocks last considered, along with which they form the mountain system of the gold region, or the gold range of Cariboo.

Apparent conformability. This implies a geological relationship. These gold schists are, as already stated, much more highly altered than any of the rocks in the Bear River series. Their junction, as observed on Antler Creek below Pleasant Valley Creek, exhibits, however, a similarity of strike and dip suggestive of conformability. But the greater degree of metamorphism is apparent at a glance and is alone good evidence of their greater age. Relative ages. Their inferior contact with gneissic and granite rocks points to the same conclusion, and the presumption is that they constitute some part of the lower Palæozoic—perhaps even pre-Palæozoic—system.

There is a certain individuality in the appearance of the gold belt superficially. The soft and friable schists readily decompose under atmospheric influences, and there is consequently a disposition to rounded forms in the outlines of the hills. Aspect. Round Top Mountain, dominating Snowshoe Plateau by some hundreds of feet, contains quartzite beds, which have resisted weathering. Mount Agnes, Richfield Mountain, Yank's Peak, and Cariboo Mountain, are prominences due to the ability of the rocks there coming to the surface, to resist weathering.

Escarpments. The northern slopes of these mountains are frequently steeper than the southern. The fact is usually attributable in Cariboo district, as it is elsewhere, to the inclination of the beds, in connection with the eroding operations of adjacent streams, facilitated and sometimes directed by the jointage of the rock. More rarely cliffs may have been determined by lines of fracture and displacement.

Strike. The strike of the rocks, as in the formations heretofore described, is usually in the direction of the mountain ranges. The entire schist or "slate belt" is furthermore characterized by an abundance of quartz-veins; and on the higher mountains these rise above the surface, and generally follow in direction the strike of the slates.

Abundance of quartz veins. In the folding to which the schists have been subjected—by a pressure exerted at right angles to the trend of the ranges—there appears to have been a tendency to fractures in a north-westerly and south-easterly direction.

The fissures resulting have afforded facilities for the percolation of

alkaline and silicious waters, the presence and prolonged action of which forming quartz, served as nature's healing agency of the fractures. Large veins are more frequent, and more remarkable on the mountain tops—Richfield Mountain, Mount Agnes, Mount Burdoll, etc.—than in the valleys.

Lithological.

Lithologically the Cariboo schists are altered sediments—clays and sandstones, with occasional small bands of limestone and calcareous shales, comprising popularly the characteristic "slate rock," where gold is looked for, in veins, and placers, by the experienced miner.

The "slate" varies from a black or bluish shale, cleaving, commonly, in the direction of the bedding, to a more or less foliated grey or green chloritic, or talcose schist; the varieties ending with typical mica-schist. The latter is the most characteristic and most widely disrtibuted of the varieties of the Cariboo "slate."

Bands of silicious and calcareous ingredients can be traced. Also bands of more or less decidedly marked mica schist, containing several varieties of mica.

In the gold region, eruptive rocks occasionally occur in the form of dykes. A dyke on the eastern slope of the Round Top summit is of hornblende rock. Dykes of "porphyry" are not uncommon.

Thickness.

As it would be unsafe, where the rocks are so frequently on edge, to draw conclusions regarding their thickness from any general section, however accurate, attention may be directed to the following distances on the Cariboo Map, where a constant dip in the same direction was observed. On Williams Creek such uniformity occurs for five miles; on Antler Creek, it occurs for four miles and a half; and along the crest of the Goose Creek Mountains, from Goose Creek to Barker's Mountain, six miles.

In Devlin's Diggings at the foot of the Williams Creek section, and again at Mink Gulch above Richfield, the attitude is vertical. Above these points are seen the usual gentler northerly dips. There is probably a repetition of beds on Williams Creek, such as is indicated on that part of the general section corresponding to it.

In that part of the section corresponding to the crest of the Goose Creek Mountains, it will be better in accordance with the facts to conclude that some beds have been inverted, than it would be to assume a thickness of 30,000 feet. The total thickness of the schists is probably as has been indicated on the section, from five thousand to eight thousand feet.

Schist belt and more crystalline, older rocks.

In delineating the schist belt, two shades of coloring are used: that of the main body (Payne's Grey) representing the gold schists on the north and west; and that of the more highly crystalline area to the south-east, exhibited on the North Fork of Quesnol River, and again

along the shores of the North Arm of Quesnel Lake, which is represented by a lighter shade of the same color.

These two areas possess certain rocks and other characteristics in common. Others are peculiar to each. The more crystalline of the schists characteristic of the gold region occur also in the eastern area, in association with coarser crystalline felspathic and quartzose ingredients. In the western area no granitic or gneissic rocks are anywhere found in place. In the eastern area, on the other hand, the Mount Stevenson group of mountains is a granitic core of the highly crystalline series.

The characteristic rocks of the western and eastern areas respectively, are seen in close proximity at Shoal Bay, a little westward of the junction of the two Arms of Quesnel Lake. They are in association with each other at several places between that and the head of the North Arm. They appear to be related, and separable only by regarding the more crystalline as an older and underlying member, re-appearing in folds in the gold region.

A belt of the eastern and older rocks was recognized on the North Fork of Quesnel River. Similar coarse crystalline rocks were observed at Cariboo Mountain; and near the wing-dam on the waggon road between Boyd's and Beaver Pass. They occur at other places in the schist belt, where their presence might be accounted for by folds of the older series accompanying the schists, although it is impossible at present to trace such connection throughout the district. **Where observed.**

Among the rocks of this eastern area are granites, gneisses, quartzites, and other of the characteristic Archæan rocks. The surface features of the country, although rounded, are rougher and more craggy than those of the gold region. **Resemblance to Archæan rocks.**

Rocks of the Alpine Region of Cariboo.

Belonging to the Cariboo Range, east of the Bear Lake trough, the rocks of Mount Mitchell were examined, and were found to be the same as the gold schists of the western area above described. Limestones occur in large masses near by, overlying the schists unconformably and with their accompanying rocks forming the crests of the range. **Limestones overlying schists.**

The latter exhibit a contrast to the schists, in their more rugged and alpine character, as well as in their greater regularity and the moderate inclination of their bedding.

Neither in the Cariboo Range, nor in the crystalline region of which Mount Stevenson is the representative, has gold been found in quantity corresponding with that of the area described as the gold region **Less rich in gold.**

proper. And though gold has been found in all the creeks, and has been more or less mined on the easily accessible ones, the fact remains that it has not been found in profitable quantities in any other part of the country under consideration, nor elsewhere than in the area of the folded schists.

Lithological resemblances.

The entire crystalline series of the gold region of Cariboo is lithologically identical, as near as can be described in general terms, with the rocks of the Pre-Cambrian and Cambrian gold regions of eastern Canada. The gneissic and schistose type of rocks of the Mount Stevenson group especially (supposed to represent the lowest horizon, on account of their association with granite in a central and massive mountain group) finds lithological representatives in the Pre-Cambrian rocks of the eastern provinces of the Dominion, and in the Appalachian axis.

Section from Guy's Mountain to the Cariboo Range.

Succession of formations.

The line of section drawn from Guy's Mountain across the schist belt of the Snowshoe Plateau, to the summit of the Cariboo Range, a distance of sixty miles, is constructed on a scale, horizontal and vertical, of two miles to the inch; the base being sea level. On it is shown the succession of the formations represented in the district; their attitude as seen at different points, in travelling across them, and their thickness, as deduced from the dips and distances along the line of section. Its course is north 40° east, therefore not exactly at right angles to the average strikes, and the mountain trends of the district.

Mining Geology.

Dip and Strike of the Country-rock.

In practical importance not second to distribution, are the dips and strikes of the several rock-formations, which have been summarized in the accompanying section. In order that the data from which the section was drawn may be further available to the miner interested in tracing quartz veins, a large number of strikes in each of the formations are shown upon the district map. All the bearings are from the astronomical meridian, the magnetic meridian being N. 26½° E.

Significance of dips and strikes.

The general agreement of the strikes with the trend of the hills and streams, in a south-easterly and north-westerly direction, has already been mentioned. It is not difficult to obtain from the attitudes of

the rocks exhibited in the section, an intelligible idea of their history as off-shore sediments of an ancient Archæan ridge, or archipelago of the Cordilleran region. Facts of importance to the quartz minor are developed by a comparison of the dips and strikes of the rocks on the several profitable placer-mining creeks. They will be more precisely shown on the creek maps, which are on larger scales. The positions and areas of the several creek maps are outlined on the general district map, along with other details which cannot be shewn upon the scale of the district map.

The dips and strikes plotted on the district map suffice to show the existence of an axial line C D which marks the position of a saddle, or anticlinal in the gold slates and schists. It lies close to some of the prominent mountains of the region, but seldom strikes through their highest points. The dips on either side of it are usually nearly vertical, though occasionally they are nearly horizontal, as if occupying the unbroken summit of an arch. The line is nearly parallel to the general strike of the schists, and equidistant from the massive limestones of the Bear Lake series, on the north-east. Anticlinal axis.

In tracing a line of this description through a country where there is a succession of wavy folds, it is not easy to distinguish the continuation of the axis of one fold from that of the next one in the series, on account of their frequent interruption by cross fractures, and by valley erosions. One such cross fracture is indicated by the dips of Beaver Pass and Ruchon Creek. It runs in a north-north-easterly direction, and corresponds with the course of one of the vein systems of Burns and Island Mountains. Another is seen in the transverse-cutting valley of Swamp River, Cariboo Lake, and of the north fork of Quesnel River, which has deflected all the strikes adjacent to that valley from their normal direction. A similar disturbance of the Mesozoic rocks occurred, judging from the plotted dips and strikes, on Quesnel Lake between its outlet and the narrows. Folds. Transverse breaks.

A clue to the identity of beds, and accompanying viens on Williams and adjacent creeks, is afforded by the limestone bands. They occur to a limited extent in the gold schist series. In the folds of the rocks exhibited upon the general section of the country in a broader manner, the limestones are seen repeating themselves in widely different attitudes. The limestones of Jack of Clubs Creek on the northern slope of Mount Agnes, those of Black Jack Cañon, and of the lower part of Barkerville on Williams Creek, as well as those of Antler Creek, and Cunningham Creek, similarly repeating themselves, will be found susceptible of identification, and correlation by means of their dips and strikes. Identity on different creeks.

Dip and Strike of Veins.

Quartz veins are represented on the Cariboo map by a heavy red line, drawn in the direction of their strike; the dip being indicated in the same manner as that of the country-rock.

Their general correspondence in strike with that of the country-rock has been alluded to. A glance at those parts of the district map which are covered by the outlines of the creek maps will show the geological features bearing on their continuations through intervening ridges and approximately their identity on the different creeks. Such identity may often be of little consequence at the distances in question, but it is noteworthy wherever traceable, especially as it is found to have a certain relation to the quantity of gold in the placer diggings of the vicinity.

Related to placers.

Openings on ledges.

Early in the history of these mines, attention was directed to the croppings of ledges noticed between Lowhee Creek, Proserpine Mountain, and the head of Grouse Creek. Openings were made on the Enterprise ledge on Lowhee Creek; on the Bonanza, Black Jack, and Steadman ledges on Williams Creek; on the Wilkinson ledge, on Proserpine Mountain; and on the Dufferin and Fountain-head ledges on Grouse Creek; all approximately in the same line of strike.

Relationship of veins to placers.

The dotted line E F is drawn along the upper edge of the richer placer diggings, from Red Gulch via Mosquito Creek, Lowhee Creek, Stouts Gulch, Williams Creek, Grouse Creek and Antler Creek to Cunningham Creek, showing a close enough relation to the series of veins which are plotted, near the same line of strike, to render additional details regarding them of interest. The depth of the superficial soil and gravel has prevented their connection being actually traced on the surface, between these different creeks. The testimony of accompanying rocks, their relative position geographically, their geological position between the top and bottom of the series to the north of the axial line of Mount Agnes, and the dip of the ledges themselves are the factors throwing light upon the question of their relations on the different creeks. Finally the contents of the ledges as given, may be investigated.

Differing dips.

A comparison of the dips and strikes of the ledges with those of the country-rock, reveals the fact that while they agree remarkably in strike, they do not agree in dip. This fact holds good in some of the principal ledges throughout the mining region. The identity of strike, and not of dip, is readily explained by the supposition that the quartz veins filled fissures which were influenced in direction by that of the bedding and the lines of disturbance during uplift. They happen to be parallel to the strike, though they are often independent of the

Vein fissures.

bedding. Veins of this description do not necessarily continue downward within the bedding to any depth; though a coincidence of the plane of bedding with the direction of the fissure or vein, doubtless frequently produced conditions favourable thereto.

Among the series of veins enumerated, the Island Mountain ledges show a southerly dip, of from 60° to 80°. The Enterprise, Steadman, and Proserpine ledges are vertical. The Bonanza, Dufferin, Fountainhead, and Nugget Gulch, and Antler Creek ledges have a northerly dip, of from 50° to 80°. All of them are in a country rock which has a prevailing northerly dip. If they belong to one system, a remarkable twist would have to be accounted for. Elsewhere at Island Mountain the northerly dips may very probably occur also. Island Mountain ledges.

The persistency of the strike of the principal ledges of Cariboo in the direction of the trend of the mountain system, co-incident with that of the schists, must be ascribed to a common original cause, that of the uplift and folding, therefore it is only incidentally related to the bedding of the schists. Causes.

Other peculiarities of these veins, including the character of their contents, are referred to below, and will be considered hereafter in giving further details of the creeks. Vein contents.

The cross-vein system of Burns Mountain is different from that last described in general direction, being north-north-easterly and nearly vertical. The adjacent country rocks dip to the south-eastward 30°, finding a parallel to their strike in the rocks of Beaver Pass and Ruchon Creek, which dip to thewestward at a similar angle. Transverse system.

On Snowshoe Plateau the ledges show an agreement in strike with that of the country-rock, yet with notable variations in dip. The ledges of Duck Creek, the North Fork of Quesnel, and of Spanish Creek vary from the country rock both in strike and dip.

Distribution of the Placers.

It is found that those parts of the Cariboo country which have a record in placer mining, can be included within the red lines G. G. and H. H., forming a circuit with a diameter of forty miles, of which Cariboo Mountain is the centre. The periphery is represented by a circular belt of about ten miles in width. It includes the diggings,—beginning at the north-west, and following the hands of a clock,—on Lightning Creek, Ruchon Creek, Willow River, Sugar Creek, Hardscrabble, Slough Creek, Red Gulch, Mosquito Creek, Lowhee Creek, Williams Creek, Grouse Creek, Cunningham Creek, Harvey Creek, Snowshoe and Keithley Creeks, Goose Creek, Duck Creek, Spanish Creek, the north Fork of Quesnel, Kangaroo Creek, Cedar Creek, the south Grouping of placers according to erosion.

Fork of Quesnel, Morehead Creek, and the main Quesnel River; and covers all of the formations described in the district; that of the gold schists being the only one remarkable for the wealth and permanence of its diggings.

A feature attending the entire list of creeks, embracing the placer mining country generally, is the width and depth of the erosions peculiar to the placer area.

Accumulated wealth in the form of placers, is simply representative of a great thickness of the country-rock, including quartz-veins, disintegrated and removed. Its metal has been concentrated, and retained, along with the heavier rocks and the harder gravels which resisted disintegration.

Higher portions of the creeks, reaching up into the mountains or into the plateaus in their vicinity, within the placer belt, it is frequently observed, have not proved correspondingly rich. This fact should not be placed in evidence against the wealth of ledges not adjacent to the richer placers, or outside of the limits of the principal placer belt. These ledges simply happen to be visible where erosion has not had the opportunity to do its work. Had the streams done an equal amount of cutting away and concentration upon them, there might have been placers in their vicinity, perhaps equally rich. Concentration by denudation being thus duly allowed for, the placer deposits will generally prove to be the most reliable indication of the wealth of the adjacent ledges.

Nature's assays.

Indications

It is well understood that angular boulders and coarse gold cannot have suffered such attrition and hammering as are incident to much travelling in the course of a stream bed. Thus the placer mines indicate first, the belts of auriferous country-rock, the streams will indicate the direction, and the transported matter itself shows the distance we have to go to the ledges, whether large or small, from which the placer gold was derived. They may justify mechanical exploitation or not, according to circumstances peculiar to the district, such as transportation, etc., quite apart from their character.

The lines of strike, accompanied by the axial line C.D., and the area of deep erosions included between the lines G.G. and H.H., furnishing respectively, the elements of identity of the rock, and of the value to be attached thereto from the testing of it by erosion, will be found to contribute materially towards confirming a judgment from nature's own hand, of the promise of the ledges on the different creeks.

Quartz Ledges Examined.

Williams Creek.—Among the ledges which have attracted the attention of the placer miners, and later of quartz prospectors, in a few instances succeeded by systematic underground mining,—are the following, with their principal features, and assay values, as found:— Quartz.

Proserpine Ledge.—At Wilkinson shaft house. Strike and dip, etc., not visible on account of the filling up of the shaft; supposed to be in line with Mason Avenue, which runs N. 47° W.; bearing to Bonanza ledge N. 43° W. The strike of the soft black slates, taken 200 feet west of the Wilkinson shaft, was found to be N. 43° W.; dip about vertical. Hence the ledge here may be considered as between beds. Body not visible. *Contents*, quartz, pyrites, ferric-hydrate, carbonaceous matter, and a little siderite. The shaft is 50 feet deep; it was sunk in 1864-66, by Wilkinson. Vein between beds.

At the Proserpine shaft house, 700 feet east from last, the attitude is about the same, the vein dipping S. < 75°; body, 10 feet. *Contents:* galena, iron pyrites, quartz, chlorite, brown oxides, and a bluish felspar. An assay by Mr. Hoffmann, of specimen containing iron pyrites and galena, in a gangue of quartz and chlorite, gave gold, 0.787; silver, 20.738 ounces to the ton. Another (No. 54) yielded only a trace of gold, and no silver. Pyrites in "slate" is said to have assayed very high. The shaft is 97 feet deep. (Filled with water.) Galena.

At a distance of 630 feet W.S.W. from the Wilkinson shaft house is the "supposed Steadman Ledge," a body of quartz striking east and west, with a southerly dip of 75°. It is in slates striking N. 33° W., and dipping north-eastward < 65°; showing local irregularity in the attitude of the country rock, and an intersecting vein system. Vein across beds.

Steadman Ledge, Richfield. A body of about four feet in width can be seen near the bed of the creek, where it has been exposed by an open cut. Strike, N. 48° W., standing about vertical. Fifty feet from it the slate rock strikes S. 35° E. and dips north-easterly < 70°; apparently in broken ground, as a hundred yards above it, and about the same distance below it on Williams Creek, the slate rocks strikes S. 65° E. and dips northward from 70° to vertical. *Contents:* A specimen sent to me by James Reid in December, 1886, obtained from a depth of 30 feet, assayed by Mr. Hoffmann, contained gold, a distinct trace; silver, none.

Hines Ledge, above Richfield. Quartz with pyrites and mineral resembling limonite. A body of quartz several feet or more in width was sunk upon by the occupant of the adjacent cabin. Depth of shaft, six feet; body of ore, four feet; direction of strike and continuity unknown. It is at the head of the profitable placer mining on Williams Creek. Contained little or nothing.

Stout's Gulch Ledge, Hydraulic Diggings, near Barkerville. An assay, by Dr. Harrington in 1876-77, of a specimen collected by Dr. Dawson, from a five-feet cross vein, containing white quartz with iron pyrites, gave gold, ·335 oz.; silver, ·131 oz. to the ton.

Vein between beds.

Bonanza Ledge, situated near the divide between Stout's Gulch and Lowhee Creek, near Barkerville. Strike of ledge N. 48° to 63° W.; dip northward < 45° to 60°; strike of slates in tunnel, N. 65° to 80° W.; dip northward < 45° to 60°. The above are repeated trials at different places. Taking an average, that of the ledge would be N. 55½° W., and of the rock N. 72½° W. The strike of a large body of quartz on the surface several hundred yards east of the tunnel known as the "Big Blowout," agrees in the main with that of the ledge in the tunnel. It is plotted on my track survey as W. N. W.; but Mr. Craib, who observed instrumentally at my request, reports its strike, N. 49° W. On the whole, I am inclined to think the Bonanza ledge runs in the bedding of the rock. Country rock, slate; showing evidences in places of fragmental origin. *Contents:* Quartz, with polished "slickenside" wall, iron pyrites, graphite, etc.

Country-rock and contents of ledges.

An assay of south casing of Bonanza ledge by Dr. Harrington (Report of 1876-77, p. 477), gave gold, ·064 ounces; silver, ·023 ounces to the ton; of north casing, only traces of gold; and of blue quartz containing slaty matter, only traces of gold.

Specimens received at the Survey Office in 1878, containing white quartz, pyrites, and some carbonaceous matter, gave gold, ·554 ounces ($11.45); silver, ·335 ounces to the ton. It had been reported as containing $90 (Rep. 1876-77, p. 478).

Erroneous assays.

Mr. Forrest states that this rock was assayed in 1878, and was reported to contain $90 a ton, but that subsequently the assays were reported erroneous. Mr. Harper, who worked some tons at Nason's Mill, claimed that it paid $3 to $4 a ton, but did not get gold enough to make a bar. No rock from the Bonanza was crushed in Riotte's time, beyond test samples.

Development work.

A tunnel several hundred feet in length strikes the ledge 55 feet below the surface, and a shaft from its inner end 50 feet deep, shows the ledge to a depth of 105 feet below the surface. Counting in the side stringers it is estimated to be 22 feet in width. Some galena is found in the hanging wall; in the foot wall the ore is all pyrites.

Uncertain strike.

Home Rule Ledge, Barkerville Mountain, half-a-mile west of lower end of Barkerville. The opening on this ledge is a hole less than ten feet wide and deep, leaving the strike and dip uncertain. Mr. Dooley, the first locator, considered it as running east and west. Mr. O'Neil, subsequently owner, considered it as running north and south, basing his conclusions on appearances in the opening. These would indicate

a ledge of about five feet in width, dipping east < 80°, having porphyry in the foot and hanging walls. There is, however, a stringer of quartz extending through this porphyry in an easterly and westerly direction, dipping S. 75°, which may represent the Dooley ledge. At a distance of 250 feet south of Mr. O'Neil's opening there is a body of mineralized quartz from five to six feet in width, striking N. 41° E., and dipping north-westerly < 80°. Twenty feet to the east of that there is a confused body of quartz separated from it by porphyry. In a southerly direction from the Home Rule opening, Mr. O'Neill found other similar croppings between these and the mouth of Stout's Gulch. *Contents:* Iron pyrites, limonite, and galena; yellow earthy oxides, ferric hydrate, accompanying pitchy looking limonite. In places along with galena, also a reddish brown, a yellow, and a white oxide. The principal characteristics of the Home Rule is its abundance of mineral in the shape of galena, limonite, pyrites, and their oxides; in which respect it is not excelled by any ledge seen by me in the district. An assay by Hoffmann of a specimen containing an association of galena, iron pyrites and limonite, gave gold, ·020 ounces; silver, 6·562 ounces to the ton.

Lead sulphide and oxide.

Dooley Ledge, an easterly extension of the last. Mr. Dooley's principal opening is about 500 feet east of the Home Rule opening, and the body of quartz disclosed strikes N. 75° W., dip S. < 70°; width, three feet. It does not show as much mineral. What there is resembles that of the Home Rule opening, except in lesser degree of decomposition. The country rock in the vicinity, a spotted slate, strikes N. 80° W., and stands vertical.. Probably, on further development, the ledge will be found to run with the slate. On the brow of the hill, back of Sincox's dwelling, the latter strikes N. 75° W., and dips N. < 75°.

Probably between beds.

Sergeant Lindsay Ledge, Richfield Mountain. Strike of main ledge, N. 69° to 76° W.; side ledge, N. 81° W. Width of main ledge, 4½ feet; side ledge, 2½ to 5½ feet. The main ledge dips S. < 50°, and the side ledge is vertical. These two bodies form a single ledge at the foot of the hill, (where the ledge has been opened), and diverge at a small angle to the westward. Country rock, grey slate, with an apparently flattish dip. It has a cleavage striking S.S.E., dip easterly < 60°. Great bodies of similar quartz crop on all sides near this ledge, and show a continuance in many different directions by smaller croppings. *Contents:* quartz with ferric hydrate and a little pyrites. A uniformly whitish barren-looking quartz, occasionally fragmental, and showing brown iron oxides in bands. Assay by Hoffmann yielded gold a trace; silver, 1·808 ounces per ton.

Veins across beds; pyrites.

Lowhee Creek.

Veins between beds; free gold.

Enterprise Ledge, 1½ mile west of the Bonanza watershed. Close to it on the west, and parallel to it in course, is Jack Pinkerton's ledge so similar in attitude, body and other characteristics that it might be described as a repetition of the Enterprise. Strike of Pinkerton ledge, N. 59° W.; dip northerly $< 85°$; width, nine feet. The ledge is about 200 feet from the Enterprise; both striking with the slate, which dips however, S. 70°. They cross Lowhee Creek about 2,000 feet below the Victoria upper shaft house, which would strike near the position of the Ralph ledge, on Barkerville Mountain. The country rock is finely laminated chloritic slate.

Not same as Bonanza.

Strike of Enterprise ledge, N. 62° W. vertical; body eight to ten feet. These ledges, accordingly, do not appear to lie in the extension of the Cariboo or Bonanza ledge. On Lowhee Gulch, where the Enterprise and Pinkerton ledges cross it, the slates hold the same strike, S. 60° E.; showing an unbroken country between; but the dip is less, being only about $< 40°$, while the colour of the rock is more greyish. George Byrnes & Co., in 1878, drifted in quite a distance on a ledge at or near this crossing. *Contents:* Quartz not containing any mineral visibly; remarkable for their perfectly polished slickensides. An assay of a specimen of "Enterprise ore," sent by W. Pollard to the Survey office in 1878, contained white quartz, pyrites, iron oxide, and slaty matter, and yielded gold, 20·096 ounces; silver 4·929 ounces to the ton. Opened by a tunnel about 350 feet long.

Intersecting galena.

Victoria Shaft Ledge.—Peculiar quartz crystals, encased in galena. Supposed by Mr. Forrest to be the western extension of the Bonanza. The Victoria was tapped 100 feet west of the shaft-house, by a tunnel running magnetic north, which cut a body of sulphurets two feet in width, but broke off abruptly to east-ward, in the direction of the Bonanza.

Sam Crane's Old Store.—Stringers yielding $20 a ton.

Island Mountain.

"*Lady of the Lake*" *Ledge,* on west shore of Jack of Club's Lake. Pyrites, and quartz, with carbonaceous matter. Assay—gold, a trace; silver, none. A tunnel was run in by Forest Dunlevy & Co., some years ago; course, W. to N.W.; continuity undetermined; body in places, eight feet. Vein lost.

Following the strike of the John's ledge from the John's tunnel eastward about 1200 feet, in sight of Jack of Club's Lake, and 300 feet back from it, bodies of quartz have been found having a similar strike, but no continuity in developments so far made. This supposed

extension of the Island Mountain or Walker Ledge, is claimed by Robert J. Walker. The rock near the lake strikes S. 65° W., dipping northward < 45°; accordingly agreeing with that of the John's tunnel.

The John's or Island Mountain Ledge, one-third to one half mile west of Jack of Club's Lake. Strike, as observed in tunnel, N. 83° W.; dip, southward < 60° to 75°. Mr. Walker gives the strike as S. 50° W. magnetic, S. 75° W. true, or 22° more to the south than I found it in the John's tunnel. The rock strikes W.S.W. to S.W.; dip to northward, < 25 or 30 degrees. A well defined pyrites ledge of 41 to 51 inches has been followed in about 50 feet. *Contents:* Iron pyrites, and quartz. A working test of a sample lot from the John's tunnel, I am informed, yielded Mr. Craib in 1887 $30 to the ton. This ledge has been supposed to be identical with the Walker ledge. It is 830 feet east of the Walker opening, and within 1500 feet of Jack of Club's Lake. The John's tunnel or Island Mountain ledge however varies in strike from that in the neighbourhood of the Walker ore-house to the extent of 20°.

Strike with rock, dip contrary.

Pyrites.

Strike changes.

The Island Mountain Company's operations during 1886-87 included the purchase of the Lane and Kurtz Mill, and the grading of a mill site on Jack of Club's Lake, at a point where the course of the western portion of the ledge would strike the Lake. From the John's tunnel it was proposed to deliver, during the winter of 1886-7, 1000 tons of quartz; and to add to the mill, concentrators, and roasting and leaching appliances for its treatment.

Development.

For several thousand feet the quartz here opened to sight, it will be observed, while not departing widely in strike from that of the slates, distinctly does not follow their bedding. The ledge shows every appearance of regularity and continuity.

Contrary dips.

Walker Ledge, 830 feet west of last. The ledge strikes S. 75° W., and dips to southward < 60°. Strike of rock in cut near ledge, S. 60° to 65° E.; dip N. < 45°. A heavy body of quartz is in sight, varying in thickness from three to six feet. The cut into the Walker ledge runs S. 50 feet, striking the ledge nearly at right angles. *Contents:* Honey-combed quartz, and brown iron oxide from decomposition, with glistening white talcose mineral resembling mica. From same locality, quartz, iron pyrites, and greenish talc. A quantity of rock milled by Riotte in 1887 (imperfectly roasted) yielded $19.03 to the ton. The bulk of the rock worked by Mr. Riotte was hauled to the Lane and Kurtz Mill, and not roasted at all. Being mostly iron pyrites, with very little or no free gold, it yielded only a few dollars to the ton. During the winter of 1885-6 Mr. Nason worked 3000 lbs. of ore from this ledge taken from the dump at the

Tests.

ore-house, and obtained $19.70. Mr. Walker reports a sample of the tailings sent to Pittsburgh for assay which yielded $61 to the ton.

Contrary dips. West of the Sadou ledge crossing, another cut ending in a short tunnel, has been run into the Walker ledge. It is 420 feet westward from the ore-house. The slate rock strikes N. 75° W., and dips northward $< 45°$; perhaps is a little disturbed. A bearing taken along its strike, as indicated by Mr. Walker from his developments here and elsewhere, was S. 79° W. About 500 feet further west in this direction, the ledge is again opened by a cut which discloses a body three feet and a half in width, nearly vertical, or dipping slightly to the south. Mr. Dunlevy owns an extension here of 1500 feet. The ledge is traced another 1500 feet west, where it is known as "Joe Mason's extension." About a mile beyond that, to the westward, are the ledges elsewhere noted having a similar strike, at the head of Mosquito Creek.

Veins across beds: pyrites

Sadou Ledge, near last; strike, S. 30° to 45° W.; attitude, nearly vertical. Mr. Walker observed it as S. 14° W., magnetic, which agrees approximately. Strike of country rock, S. 55° W.; dip, northward $< 45°$. The Sadou ledge is opened by a short tunnel, several hundred feet to the westward from Walker's opening. It is a ledge crossing the above named; body, 2 to 4 feet. *Contents:* A milk-white quartz coated with hydrated peroxide, having pyritous cavities gave, gold, ·658 ounces; silver, ·233 ounces to the ton. Assay by Harrington, in 1876-7, of rusty quartz, with mica slate, from the Sadou ledge gave gold, ·175 ounces; silver, ·802 ounces to the ton.

The Sadou claim runs 600 feet in the general direction of the ledge up into the mountain, taking in a width of 100 feet. It is owned in Paris. At the bottom of the cut there is evidence of a fault, in quartz lying near to, if not belonging to the ledge.

Fault.

Veins across beds.

Fox Ledge.—Near last; strike, W.S.W., dip, southward $< 85°$. Country rock, slate; strike, S.W., dip, N.E., $< 40°$. An irregular broken ore body of considerable extent. *Contents:* An abundance of iron pyrites, and iron oxides containing free gold. Yielded colors of gold after roasting. An assay of selected ore is said to have yielded $60. 00 and $70.00 to the ton.

Veins across breakage.

Wright Ledge.—Near last; strike, south-westerly, nearly vertical. Strike of country rock, S.W., dip, N.W. $< 30°$. Body, 2½ feet, and less. *Contents:* Pyrites &c. Assays are said to have yielded $50.00 to the ton. The ledge lies along the tunnel, which is in the strike of the rock, for the first twenty feet; then diverges it on the right hand of the tunnel. The tunnel runs S.W. 150 feet; then S.S.W. 170 feet; total, 320 feet.

Galena.

Atcheson Ledge.—A small ledge between the Fox and Wright. *Contents:* galena, with other ore.

The Fox, Atcheson and Wright ledges have some appearance of breakage, which may also affect the Sadou and Walker ledges.

About 200 feet eastward from the mouth of the Wright and Atcheson openings, Mr. Walker, in 1869, ran a tunnel south, 124 feet in length, nearly at right angles to these ledges, without striking them; showing that they pass more to the north; and further proving, that the Walker ledge does not, as it should not, pass in that vicinity.

Soda Co.—Mr. Walker informed me that about 2,000 feet west of the Dunlevy cut above mentioned, Flynn & Co. under the name of the Soda Co., have located a ledge which crosses the Walker, striking N.W magnetic, (W.N.W. true), is four feet wide, and yields an assay of $38.00 to the ton. **Vein across beds.**

The Sadou ledge, and some bodies of quartz showing on the mountain near the "Lady of the Lake" facing Jack of Club's Lake, correspond in course and attitude with some of the ledges of Burns' Mountain, four miles further south.

Mosquito Creek.

Ledge in Saunders placer diggings.—Strike, N. 62° E., dip, north-westerly, very steep. Strike of country rock, S. 75° W., dip northward $< 80°$. Body, one foot to two feet and over. *Contents:* Quartz, and felspar, with ferric hydrate, and a little iron pyrites. Chlorite and white mica with nests of pitchy iron oxides are also characteristic. An assay by Hoffmann yielded a trace of gold; no silver. **Vein between beds.** **Altered strike.**

Ledge near Flynn's lower diggings, where float galena in large masses, from adjacent ledges not identified, gets into the sluices. Assay by Hoffmann yielded, gold, 0.182 ounces; silver, 36.458 ounces per ton. **Galena.**

Ledge in Flynn's upper diggings, 500 feet above last, large irregular bodies of quartz are seen in place. *Contents:* a little pyrites, and a white talcose mineral. An assay by Hoffmann yielded a trace of gold; no silver. These are the uppermost placer diggings on Mosquito Creek.

Six hundred feet further up Mosquito Creek forks; in the forks a tunnel has been run into the hill 500 feet, intersecting two or three quartz ledges of moderate size. Their course is easterly and westerly. One contains a great deal of galena, and is probably the source of the numerous specimens of that mineral found in Flynn's placer mine. The other contains sulphuret of iron. **Normal strike.**

Ledges at the head of Musquito Creek.—One mile from Flynn's cabin. Supposed Island Mountain or Walker Ledge. Course, E. and W. magnetic=N. 64° W., dip S. Body about five feet. *Contents:* Galena, with white and yellow oxides. **Dip contrary.**

Lightning Creek.

Veins across beds.

Beede or Perkins' Ledge, on Burn's Mountain, one mile and a quarter north of Lightning Creek. Strike, N. N-E., vertical; differing from that of the slate. The country rock graduates from slate to shale; in some places it is plainly unaltered from sandstone. It is a soft chloritic rock, in places; silicified, in others, and in the Burns' Mountain Company's tunnel it is hard to drill. Strike, N. N. W.; dip, eastward $< 30°$. Body from six to eighteen inches, sometimes widening to three feet or more. There are several ledges of this sort near each other. *Contents:* Quartz, with galena, ferric hydrate and iron pyrites. The quartz is usually honeycombed from decomposition of the pyrites, resulting in dark brown, bluish and blackish oxides. Accompanying the galena there are white and dirty yellow oxides. An assay by Mr. Hoffmann of quartz carrying a little galena, gave gold, 2.625 ounces; silver, 3.033 ounces to the ton. Another, holding more galena, yielded gold, 0.365 ounces; silver, 29.896 ounces per ton. Free gold shows in fine particles after roasting and washing. Development work consists of a tunnel (the Reid) about three hundred feet long, and several shafts, fifty to seventy feet deep, with connecting drifts and stopes. Several hundred yards north of the Perkins shaft is *the Laura Ground*, on one of the Beede series of ledges which has been extensively opened by the Cohen incline, etc.

Development.

Striking with rock, dip contrary.

Burns' Mountain Company's Ledge, on Burns' Mountain, two miles north of Lightning Creek. Strike of ledge, N. 36° E. (as traced on the surface by Mr. Jacques), attitude, vertical. Strike of country rock, N. 35 E., dip, south-easterly $< 30°$. Body in main shaft, two feet and a half to five feet. *Contents:* Iron pyrites and galena, with yellow oxides. Assays various, including some visible free gold.

Breakage.

At their principal shaft the Burns's Mountain Company has sunk on a ledge five feet wide at the surface, to a depth of about fifty feet. In the last half of that distance the ledge suffered a break; the quartz diminished to two feet and a half; pinched out, came in again in considerable force, but its further continuity has not been determined. Selvedge lines and gangue, with broken rock, filled the place of the vein where broken.

Development.

From a point on the northern slope of the mountain, one hundred and seventy-four feet lower than the shaft house, a tunnel has been brought in, over eight hundred feet in length, to a point vertically under the shaft. Two series of veins were intersected, running N.E. and N. 30° to 36° E. respectively. During the season of 1886 they were drifted on, and prospected under the superintendence of Mr. Jacques.

Silver Ledge, Burns' Mountain Company. Galena and pyrites.

Strike, N. 30° E.; body two feet; in tunnel, very small. Assay by Hoffmann gave gold a distinct trace; silver, 3·442 ounces per ton.

Ledges near junction of Van Winkle and Lightning Creeks.—On the north side of Lightning Creek, opposite the old Van Winkle Company's headquarters, there is a small ledge which strikes N.W.; dip, N.E. <55°; thickness, two feet, with parallel seams of smaller size. This is on an island of bed rock, between the Point claim and the present Van Winkle Creek. In the rich Placer ground of the Point claim, in 1875, four men, working in two shifts, took out five hundred ounces of gold a week. *Contents:* Quartz with chlorite and a little ferric hydrate. An assay by Hoffmann gave a trace of gold; silver, none.

Veins between beds; pyrites.

On the south side of Lightning Creek, nearly opposite to the last, a little lower, and directly opposite to the Van Winkle dump, is a small ledge or stringer which strikes S. 72° W., and dips southerly < 40°, following the strike and bedding of the country rock. Body, six inches. *Contents*, quartz with chlorite and ferric hydrate. An assay by Hoffmann gave a trace of gold; silver, none.

Striking with rocks, dips contrary.

From this point for three hundred feet down Lightning Creek, was the richest placer ground on the creek. David Edwards, who cleaned the bed rock in drifting, states that quartz was visible in considerable quantities under-ground. A large mass of it was found on a bench on the north side, about two hundred feet below first mentioned. No ledge was visible under the creek, so far as he knows.

Above the junction of Van Winkle Creek, three or four small ledges cross Lightning Creek, between Van Winkle and Eagle creeks.

Vein across Lightning Creek.

Sam. Montgomery's Ledge, quarter of a mile above Stanley. Strike (from information), about S. 30 E. Body, two to four feet. *Contents:* Quartz with a little chlorite and limestone. Barren-looking. Assay by Hoffmann gave a trace of gold; silver, none.

Mr. Montgomery reports a ledge uncovered in the diggings at this place about 1876, which had a strike of S. 30° E., as nearly as he can recall it, and a width of four feet. It is probably indentical with the ledge from which my specimens were obtained,—cropping under the bluff on the south side of the Creek, a little above Montgomery's cabin.

At the timber shaft, about 100 feet farther up, a "rotten ledge" was uncovered, from four to six inches in width, which crossed the creek in the same direction. The diggers sunk into the rotten ledge four feet, all along its course, and washed the loose stuff, which yielded the best prospects in the claim. Montgomery got coarse gold out of it, $4.00, $6.00, and an ounce ($18.00) in weight. About six hundred ounces of the coarsest gold in the claim was taken out of this rotten ledge.

Rotten ledge.

Stringers.

Chisholm Creek.—One mile and a third north of Stanley. Lowest ledges or stringers found near rich placer ground just above Sam Montgomery's old placer diggings. Small veins of barren-looking quartz. Strike E.S.E., dip northerly <50 degrees; body ten to twenty inches. *Contents:* Quartz with a small quantity of chlorite and ferric hydrate. Assayed by Hoffmann, gave a distinct trace of gold; silver, none.

Vein across beds.

The diggings were worked in 1863–4, and paid \$50.00 a day to the hand—the richest on the Creek. While these ledges may have contributed to the results in part, the probability is that most of the gold was from ledges further up.

Two or three series of ledges with a similar strike are found between this locality and the junction of Oregon gulch. Here a narrow vertical ledge crosses the gulch at its outlet, in a northerly and southerly direction, showing excellent ore.

"*The Foster Ledge*" is in this vicinity. It is tapped by a tunnel running W. to S.W., a hundred feet above the junction of Oregon gulch, not now accessible. It was at one time the subject of much attention, founded on finds in the placers of its vicinity. Its strike is said to be south-westerly.

Sugar Creek.

Cooper's Gulch.—A little over half a mile above its mouth. A two feet and a half vein containing plenty of mineral, pyrites and galena, with ferric hydrate, chlorite, felspar and quartz. An assay by Hoffmann gave a trace of gold.

Galena Ledge.—Two thousand five hundred feet up Cooper's gulch. This may be identical with the Galena ledge crossing Sugar Creek a mile above Cooper's Creek; striking in that direction. Body two feet and a half, weathering into a hollow in the hill side. *Contents:* Quartz with a little galena, (often coated white) and iron pyrites. Assay by Hoffmann yielded distinct trace of gold; silver, 0·525 ounces per ton.

Forks of Cooper's Gulch.—Near last. Barren-looking quartz with white talc. Strike, S. 80° E., dip, N., nearly vertical.

Up the S.S.E. branch one quarter mile, another ledge crosses, striking S. 50° E., and dipping southward $<70°$ in which there is nothing visible at the point of crossing. Mr. Wiley thinks it is the same ledge which shows on the point of the mountain about half a mile to W.N.W. in good body, containing at that place an abundance of iron sulphurets.

Vein across beds.

Ledge in Wiley's Old Diggings, at mouth of Cooper's Gulch on Sugar

Creek, (containing conglomerate cement boulders). Strike S.W. A ledge of good body, two or three feet, and fine looking ore, but undetermined continuity. *Contents:* Quartz, pyrites, and brown oxide. Assay by Hoffmann gave a distinct trace of gold; silver, none. The placer ground was rich in its vicinity. Mr. Wiley attributes it to the ledge.

Upper Ledge in Cañon above Wiley's house; strike of ledge N. 80° E., dip northward $<75°$. On the north-side of Sugar Creek a body of quartz six to eight feet in thickness stands above the surrounding surface. *Contents:* Quartz with iron pyrites and a little copper pyrites. Assay by Hoffmann gave a distinct trace of gold; silver, none. **Vein across beds.**

Fifty feet above the creek on the north side there is a bench which was worked by Mr. Wiley ten years ago. It yielded $4.00 a day near this ledge, and $2.00 away from it.

Lower Ledge in Cañon, 150 feet below last. This strikes N.W. and S.E., and dips to southward $<70°$; accordingly crossing the last mentioned on the bench. At the edge of the creek on the E. side there is a body three feet in width, which appears to be a bunch—continuity doubtful. Country-rock, slate, strikes N.W., dip northward $<70°$. *Contents:* Quartz with reddish weathering siderite, and ferric hydrate. Assayed by Hoffmann yielded distinct trace of gold; silver, none. Another specimen showing, along with quartz, siderite, and ferric hydrate, also chlorite, and a small quantity of blende, yielding on assay, a distinct trace of gold; silver, none. **Veins across beds.** **Carbonates.**

This ledge crossing the last mentioned on the bench described, at or near the crossing contains copper pyrites, malachite, and a pitchy ore probably a copper sulphuret. **Copper.**

Ledge at Ditch waterfall, near Wiley's cabin. Strike with slates S. 55° E.; but not following their bedding. It dips southerly $<60°$, while the slates dip northerly about the same amount. Body, two feet. *Contents:* Brown iron oxide in moderate quantity. It yielded gold appreciably, in the sluices of the adjacent placer mines, although not containing much mineral visible to the eye. **Strike with rock: dip contrary.**

Ledge at Wiley's cabin, (passing under woodshed). About 200 feet below last, striking with the slates. Body, 2 to 2½ feet. Continues through the diggings; east of the creek enters hydraulic diggings near the Walker tunnel. *Contents:* Quartz with iron pyrites coated black, ankerite, ferric hydrate, chlorite, and a small quantity of blende. Specimen assayed by Hoffmann yielded gold, a trace; silver, none.

Dirt from its vicinity thrown into Wiley's sluices, yielded a different gold from that of the placers overlying it. Gold is invisible to the eye in specimens.

Lower Diggings Ledge.—Still another ledge crosses the creek about the middle of the lowest placer bench worked to bed-rock, a quarter of a mile below Wiley's house. Strike, N. W. & S. E., vertical; body, 2½ to 4 feet. It contains an abundance of sulphuret.

On Mustang Creek, which enters Sugar Creek half-a-mile below Wiley's, there are several quartz ledges seen crossing Isaac's placer diggings diagonally. These diggings are two miles above the mouth. Wiley supposes these ledges to be the continuations of those of upper Cooper's Creek.

Grouse Creek.

Vein between beds; iron sulphide.

The Clear Grit Ledge, situated on Canadian Creek, two miles east of Barkerville, strikes apparently with the slate country rock, N.W., and is, like it, vertical in attitude. Body, five feet. *Contents:* Iron pyrites with the usual accompaniments, in abundance.

The Fountain Head Ledge, on Grouse Creek, is situated at the head of the placer diggings above Cañon Ravine, and strikes N. 52° W. dip northward $< 65°$; having nearly, if not precisely, the same attitude as the country rock. Body, ten feet, running in parallel stringers, which are separated by selvedges. The vein does not show on the East side, but ought to go through the Ottawa Company's placer claim. *Contents:* Quartz with a little chlorite and ferric hydrate; iron pyrites weathered out of a honey-combed quartz. An assay by Hoffmann gave a distinct trace of gold; silver, none.

It has been little more than touched; while its position and appearance would seem to warrant prospecting it. Notable on account of paralellism of quartz deposits.

The Lady Dufferin Ledge at the head of the creek, strikes S. 65° E.; dip northward $< 70°$, with the country rock. Width, five feet nine inches. *Contents:* Iron pyrites with oxides, quartz, and carbonaceous matter. It contains rather a barren-looking quartz. Iron sulphurets in stringers are seen running into the slate hanging wall. Assay by Hoffmann yielded gold, 2.042 ounces; silver, 0.292 ounces per ton.

Twist and breakage.

The ledge has been exposed by a tunnel sixty-five feet long, running S. 75° W. The ledge is named the Lord Dufferin on the east side of the creek. Here its strike, as seen at the surface, appears to be S. 25° E., dip northward $< 60°$; but on entering the tunnel it is S. 80 to 85° E., dipping from nearly vertical to $< 50°$ northward—showing a displacement by a twisting movement. A porphyry streak of six inches divides the ledge. From stray pieces it is supposed that additional porphyry dykes exist which had, probably, a good deal to do with these disturbances. The country rock is a spotted bluish slate, which falls down in large angular blocks, often knotty in appearance. It has been exposed by a tunnel run S. 25° E. to a depth of 175 feet.

Porphyry.

Antler Creek.

Porter's Ledge on middle Antler Creek is a little below the old town of Antler, on the west side. Two ledges here show, within 50 feet of each other. The upper one is best seen above the trail and several hundred feet back. Strike E. S. E., dip to southward <80°. These ledges show also in the creek, and beyond it, several hundred yards E. S. E. Body, unknown. *Contents:* Quartz and a little chlorite, with ferric hydrate, running from brown to blackish in parts; weathered specimens showing also yellow and white oxides. An assay by Hoffmann showed a trace of gold; silver, none. Southerly dip; iron and lead sulphides.

The lower ledge shows a large body of ferruginous matter, with some fine-looking quartz. Body and character cannot be determined without digging.

Pebbles of ironstone are found in the sluices of the Yellow Lion Co. at McBean's Flat. Where these pebbles are found on Antler Creek, it is said there is gold found with them. They are jaspery in appearance, approaching hematite in the quantity of iron they contain; and were probably derived from a ledge, which in depth becomes pyritous. Pebbles, ironstone.

The Limestone Ledge of Nugget Gulch, half a mile above Porter's house, strikes and dips with the country rock, and has a body of several feet in thickness, blending into limestone. *Contents:* Ankerite and ferric hydrate. An assay by Hoffmann showed that it contained neither gold nor silver. Nugget Gulch in the vicinity has been mined for 1,000 feet up from its junction with Antler Creek, and the source of nuggets had been attributed to the limestone ledge. Further up, Nugget Gulch has not been prospected to bed-rock. Vein between beds; iron carbonate.

Round-Top Mountain and Cunningham Creek.

On Round Top Mountain there is a comb of quartz or quartzite which is evidently too massive to be anything else than barren. The summit itself is mostly quartz, or quartzite, which strikes with the rest of the country rock; strike N. 80° W., dip northward < 40°. Vein between beds; iron oxides.

The "Big Ledge," or comb of quartzite on the eastern member of Round Top Mountain, one mile S.E. of last, contains oxides of iron in small quantity, with very little pyrites. Strike more to the S.E. than on the main summit; dip, also northerly, but steeper. Country rock, slate. This comb runs from one-quarter to three-quarters of a mile E.S.E. from our Round Top camp, striking over the summit of the eastern mountain. Slides from it, on the N. side, show oxides of iron in sufficient quantity to colour the side hill of the northern escarpment red, visible at a mile distant.

Between beds; sulphide.

Ledge on Cunningham Creek, near the head of Sharp's Ditch, two miles west of Round Top, and 100 feet above the ditch. Course, N.W. and S.E., with the rock; dip northerly less than $< 48°$. Quantity of ore considerable, but the continuity has not been proved. *Contents:* Iron pyrites, nearly pure; also decomposed products, with quartz. An assay by Hoffmann showed a very distinct trace of gold; silver, none.

Between beds; carbonate.

Ledge in Sharp's Diggings, Cunningham Creek. This is called the "Big Iron" Ledge, and is an iron stained ledge or dyke, containing pyrites. Its attitude is that of the country rock, which is slate and limestone. *Contents:* Ankerite, with a little quartz, chlorite, and some ferric hydrate. The assay by Hoffmann showed a trace of gold; silver, none.

Unknown ledges.

At the Chinamen's Diggings, on the western hill-side, half a mile below Sharp's, great numbers of quartz boulders are found scattered, indicating proximity to a ledge of good character, not yet discovered. The digging in 1886 yielded well. It is a side-gravel deposit of local origin.

Snowshoe Plateau and Snowshoe Creek.

Vein across beds; lead, iron and zinc sulphides.

The Holmes Ledge, Breakneck Ridge, head of Six-mile Creek, on the Antler trail, strikes east and west; attitude, nearly vertical. It is in a comb of slate extending down from the Mountain, the country rock striking N.W., dip N.E. $< 70°$. Cleavage lines of large masses appear to correspond with the strike of the rock. Body of ore very considerable, in the shape of nests from three to six feet in width, the continuity of which has not been determined by openings. *Contents:* Galena, and iron pyrites, with zinc blende, accompanied by white oxides; galena in considerable abundançe. A sack of the ore was sent to San Francisco for a working test, which resulted very favorably, having yielded, it is said, a profit to the owner, above cost of test.

Veins between beds; free gold.

Haywood's Arastra Ledge, one-quarter mile north from upper Little Snowshoe Creek, strikes S.S.E., and dips eastward < 45 deg., like the country rock, a grey slate. Body, six to eight feet, as seen in a shallow prospect hole of the same dimensions; not further determined by exploration. *Contents:* Pyrites in quartz, with ferric hydrate, chlorite, and (reported occasionally) free gold. The quartz is a good deal honeycombed, from decomposition. A specimen assayed by Hoffmann yielded gold, 0.408 ounces; silver, 0.058 ounces to the ton. Another showed a distinct trace of gold; silver, none.

A tunnel was run in by Mr. Haywood many years ago to tap the ledge. Its direction was N. 6 E., and length, 90 feet. It did not follow the ledge; and very little can be seen from the developments, of

the character of the ledge. Prospect ditches, and openings made by Haywood proved, however, an abundance of quartz.

An arastra located on the ground was unprofitably worked by Mr. Luce. Its name was originally the Douglas ledge. Mr. Haywood reports that he found visible gold all the way down, from the day he commenced prospect work, to the bottom of his hole, which was located on the richest place at the surface. Arastra.

His tunnel was on one side of the ledge, crossed it diagonally, and then kept alongside. About 40 feet in, was obtained the mineral now seen on two dumps. Various stringers three or four inches in thickness were crossed, besides the main ledge.

A ledge on the top of the hill, 1,400 feet N.N.W from the Arastra ledge, also follows the strike of the rock. There is quartz scattered all over the top of the hill.

The Snowshoe Creek Rich Boulder Ledge, never identified, was the ledge sought in the Arastra location. The only other ledge ever found on Little Snowshoe, besides the Arastra, in proximity to the placers, is on the point 200 yards below Smith and Anderson's hydraulic diggings. In 1874, Mr. Haywood ran a tunnel to find a high rock-bed bench of the channel, and found this ledge. It contained a good deal of galena. What struck him was, that it appeard to be the same kind of rock as the rich quartz boulders for which the Little Snowshoe Creek placer diggings have been noted, containing galena and free gold. Boulder; specimens. galena and free gold.

The Arastra ledge did not contain exactly the same kind of quartz as these boulders; galena was lacking. Other ledges and stringers near it, however, above and below the Arastra, contained galena. About 200 yards west of the Arastra, still another ledge was found, running S.W., which contained galena.

On Horseshoe Gulch, forming the extreme north-easterly source of Little Snowshoe Creek, several ledges and stringers are seen crossing the gulch diagonally, in the strike of the slates; course, N. 30° W. *Contents*, of ledge noticed, quartz and galena. Vein between beds; galena.

The Steele Ledge is on the dividing ridge between little Snowshoe, and French Snowshoe creeks; containing honey-combed quartz and brown iron oxide, with blackish parts. Several bodies of quartz a few feet wide show on the surface, without much appearance of continuity; nor containing much visible mineral. Developments, about 18 inches sunk on ledge.

The *Galena Ledge*, near by is supposed by Haywood, to be in line with the Arastra Ledge; being S. 21° E. from Arastra Ledge three quarters of a mile; on spur forming the north-west side of Yank's Peak, one fourth of a mile from summit. It is in line with the tunnel ledge on French Vein between beds; galena.

Snowshoe, which figured during the quartz excitement of 1878. Chunks of galena are found on the surface immediately below this ledge. Mr. Haywood supposes the galena in the Little Snowshoe placer mines to have been derived from it.

The "Big Ledge," on the S.W. side of Yank's Peak, claimed by Haywood and Rawley, strikes north and south, and according to Haywood, standing vertical, shows only scattered croppings to speak for itself.

Veins between beds: galena.

Galena Seams and Veinlets.—A mile below the Arastra, and about 100 yards below Haywood's present house, Haywood, in 1876, found a seam of galena an inch thick, on the east side of Little Snowshoe Creek, in plumbaginous black slate, along with a scraggy, sparry quartz. It was in the strike of the rock, running from S. E. to N. W. Near the same locality on Little Snowshoe Creek, pyrites occur in association with a felspar weathering red, in the rocks cut through by the creek.

On Harvey Creek.

Veins between beds; iron sulphide and carbonate.

The Ironstone Ledge, one-quarter mile below falls of Harvey Creek. Olive and bluish felspar with iron pyrites. Over three feet in width. Strike east and west; dip, N. $< 60°$; with the slates apparently. It is from three to eight feet wide, and is repeated in another locality near it. *Contents:* Siderite, with magnetic pyrites and a little iron pyrites; a great body of metal, being nearly solid ore. Assay by Hoffmann showed a distinct trace of gold; silver, none.

The ledge weathers red on the surface. Projecting into the creek, boulders from it strew the placer mines below.

Duck Creek.

Veins across beds; lead, iron and zinc sulphides.

Ledge 300 feet above the Forks Trail crossing. Strike of ledge S.W.; attitude, vertical. Strike of country rock in the vicinity E. and W., dip, north. Body two to four feet. *Contents:* Galena with white and yellow oxides, a small quantity of iron pyrites, zinc blende, reddish oxides, and opaline hornstone. Assay by Hoffmann showed a trace of gold; silver, 3.850 ounces to the ton.

A surface cut was made in 1878 on the north side of the creek, disclosing considerable quantities of galena. On an adjacent discoloured bluff of country rock, an excitement was raised 25 years ago, owing to placer finds supposed to have been traced to this vicinity.

Borland Ledge, two miles above trail crossing; strike, S.W.; attitude, vertical. Strike of slates in the vicinity, S.E.; dip, southerly $< 25°$. A body of four to five feet in width crops out on the N. side of the creek, into which a shallow cut has been made. *Contents:* Quartz

with iron pyrites and chlorite. Assay by Hoffmann showed a trace of gold; silver, none.

In the winter of 1878, the Chinese, supported by the merchant Ching at Quesnel Forks, took great interest in this ledge, and worked at and around it the greater part of the winter, without accomplishing much. It was believed to be rich.

North Fork of Quesnel River.

Moore's Ledge.—A ledge is reported by Mr. James Moore cropping at low water on the left bank of the North Fork 100 yards above the mouth of Spanish Creek. It crosses the river at right angles. Body, three feet.

Below Spanish Creek the bed of the North Fork was found rich; above it, poor in gold. **Placer gold.**

Ne Tye Ledge.—A mile below mouth of Spanish Creek Chinese hydraulic diggers near old Diller tunnel, exposed ledge in washing. Strike, N.W., dip, N.E. $< 60°$. Slates strike east and west, dip, north eight degrees. Body, one to four feet; irregular in continuation. *Contents:* Quartz with ferric hydrate, from decomposed pyrites. Assay by Hoffmann showed a trace of gold; silver, none. **Vein across beds; iron sulphide.**

The Diller tunnel was run into a point on the right bank, intersecting a ledge in this vicinity.

The Stephenson Ledge also on the right bank, one mile and three-quarters below the mouth of Spanish Creek, was opened by shaft and tunnel in 1878. Body and contents, unknown.

Spanish Creek.

On Spanish Creek there are seven or eight known ledges, reported by Mr. Moore. A mile above its mouth there is a ledge two feet wide, not containing any sulphurets. There is a ledge from five to seven feet in width at the meadows, near the outlet of Black Bear Creek. It contains galena in streaks about an inch wide, and strikes N.N.E. Another, a mile up Black Bear Creek, is six inches wide, and consists of decomposed quartz. Above that, one mile and a half is a ledge four feet wide containing iron pyrites. These ledges run in the same general direction. **Numerous ledges.**

While working placers on Black Bear Creek, Mr. Moore frequently found pieces of pure galena weighing from one ounce to ten pounds, and many quartz boulders containing galena.

South Fork of Quesnel River.

Gold in conglomerates.

Between Quesnel-Forks town, and Quesnel Lake, a nine-mile stretch of Quesnel River has been designated as the South Fork. In the placers accompanying the river here on high shelves of bed-rock, quartz boulders occur along with iron pyrites, and their rusty decomposition products, derived from the newer mesozoic rocks of that region. A soft conglomerate is picked by the miners, in order to wash it; and its metallic contents are seen to have led them occasionally far up on the hill sides, above the bed of the old river channel. Much of the gold on this stream, accordingly appears to be a secondary deposit. Veins in this area are certainly less numerous, and have attracted little attention in connection with the placer deposits.

Between the Main Quesnel and Swift Rivers.

Vein across beds, free gold.

The Dominion Ledge on western end of Cariboo Mountain; strike N. 85° E.; dip, southward, < 80°. Body, eight to ten feet. It plunges down, and follows midway the steep northern escarpment of Cariboo Mountain. It is conspicuous above the surface, from six to twelve feet in width, for one third of a mile. Beyond that to westward and eastward, its identity becomes less certain, mingling with neighbouring croppings. Although broken fragments are found to the westward in the line of strike, the appearance is that of a diminution in strength in that direction. Cross stringers occur plentifully. Country rock, grey slate. Three quarters of a mile to the westward, black slate succeeds the grey. Strike of country rock, N. 40° W., dip, S.W. < 50°. *Contents:* A barren-looking white quartz, in some places stained light yellow. Specks of free gold are visible occasionally.

Development.

Development work has amounted only to the removal of about 100 cubic feet of rock from the surface of the ledge. Several miles to the westward, on or near the strike of the vein, Mr. Porter panned gold out of the surface dirt, at a point where the mountain slopes down into the valley of Swift River.

Hixon Creek.

Veins between and across beds.

Quesnel Company's location on Washburne Ledge. Strike N. 46° W., dip N.E. < 70°, with the slate country rock. Body from 6 feet to a few inches. Cross-veins of less body, striking N.E. and standing vertical, contain richer ores. *Contents:* Iron pyrites, grey copper, and their decomposition products, with free gold. Assays by various parties, from $28.00 to $274.00, averaging over $70.00 per ton, in gold and silver.

The main shaft is 200 feet deep. The Mason shaft, several hundred feet north of it at the base of the hill, is 40 feet deep; and the Koch shaft is 70 feet deep. Development.

Three more or less crooked prospecting drifts have been run northwestward into the hill, searching for a continuous ore body. Following bodies of quartz, in several instances the general course was with slates, as given above. The oldest of these was run by Buckley and Washburne, the next by G. B. Wright and Coleman, and the last by the present company, under the superintendence of Mr. George Koch. The last mentioned was the only one in 1886 open to inspection. It starts from the bottom of the Koch shaft, and is 174 feet long. The others start in at the surface level, and are about two-thirds that distance in length.

From the main shaft, drifts have been run along the strike in opposite directions, and also along the cross-veins, in opposite directions; and in other directions, at different depths, and in different places, amounting to a large aggregate of exploratory work. The lack of continuity in the ore bodies found near the surface, and the smallness of the rich cross-stringers, has been baffling. The main shaft having been deepened in 1887, a short drift to the north-east disclosed a large and promising ore body. Ore bodies.

of Canada

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR.

NOTES

TO ACCOMPANY A PRELIMINARY MAP

OF THE

DUCK AND RIDING MOUNTAINS

IN

NORTH-WESTERN MANITOBA.

BY

J. B. TYRRELL, B.A., F.G.S.

Field Geologist of the Geological and Natural History Survey of Canada.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

MONTREAL:
DAWSON BROTHERS.
1888.

To ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S.,

Director of the Geological and Natural History Survey of Canada.

SIR:—I beg herewith to submit a preliminary Contour Map, with explanatory notes, of the Duck and Riding Mountains and the adjacent valley of the Assiniboine. The country depicted and briefly described lies chiefly within the province of Manitoba, but a strip of the eastern portion of the district of Assiniboia is also included.

I have the honor to be, Sir,

Your most obedient servant,

J. B. TYRRELL.

NOTES

TO

ACCOMPANY A PRELIMINARY MAP

OF THE

DUCK AND RIDING MOUNTAINS

IN

NORTH-WESTERN MANITOBA.

North-western Manitoba.

The present map embraces the area travelled over, examined and surveyed during the summer of 1887. In it are incorporated all the Dominion Lands, Indian Reserve, Timber and Railway Surveys up to the present date. It forms the south-west corner of a larger sheet embracing also the whole of Lake Winnipegosis and part of Lake Manitoba. This sheet it was hoped would have been ready for publication during the present winter, but during the early part of the summer of 1888 the writer was seized with a severe attack of fever while in the vicinity of Fairford House on the Little Saskatchewan River. Two weeks were occupied in carrying him to Winnipeg, where he lay in the hospital for seven weeks, and was unable to resume field work before the winter set in. This checked the progress of the exploration to such an extent that another season must necessarily be spent before the whole map can be ready for publication.

Its importance.

In view of the utterly unknown character of a large part of this region, of its great importance as a source of timber supply for Manitoba, and of the luxuriant fertility of the soil over considerable areas such as those drained into Lake Dauphin and the Assiniboine River, this map is now submitted for publication in advance of the larger sheet.

Surveys.

It has been compiled and drawn by Mr. D. B. Dowling, B. Ap. Sc., who also acted as my assistant in the field. In its preparation I have received every possible assistance from Capt. Deville and the gentlemen associated with him in the Dominion Lands Branch of the Department of the Interior, and also from Mr. Collingwood Schreiber and

others in the Department of Railways and Canals. Wherever surveys of townships or Indian Reserves have been made by the Dominion Lands Branch, these surveys are marked by full lines. The old locations of the Canadian Pacific Railway, both north of the Duck Mountain and south of the Riding Mountain, have furnished valuable lines through the country. For the rest, the topography is laid down from odometer and track-surveys made by ourselves, frequently checked by latitudes taken with a brass sextant of eight-inch arc reading to 10″. The contour lines are laid down from the heights given on the two railway-surveys just mentioned, as well as from numerous heights obtained from observations made with a mercurial barometer and two aneroids, compared with the readings taken thrice daily from the standard barometer at Minnedosa. The height of the standard barometer at Minnedosa is 1689 feet, a height twenty-four feet higher than that given by the railway profiles, an error of this amount having been found by Mr. Warren Upham to have been made in connecting the surveys east of the Red River with those to the west of it.

Extent of country mapped.

The map as now published embraces an area of 12,000 square miles, but of this, Lake Winnepegosis is merely sketched in from former surveys to show the discharges of the various streams, and the Porcupine Mountain, in the north-west corner of the map is as yet unexplored. This leaves an area of 8,500 square miles, or 5,440,000 acres, a tract larger than that of the State of Massachusetts, which has been more or less carefully examined. It embraces Duck and part of Riding Mountains, with the included and surrounding valleys and the more level country east of these mountains, lying between them and lakes Winnipegosis and Dauphin. It is drained on the north by Swan River, which flows north-eastward through Swan Lake into Lake Winnipegosis, its main tributaries being the Bear's Head, Favell, Rolling and Sinclair rivers, flowing northward from the north face of the Duck Mountain. On the west, it is drained by the Assiniboine, with its tributaries Little-Boggy and Big-Boggy creeks and Shell River. On the south, some of the small upper tributaries of Bird-tail Creek drain a limited area in the Riding Mountains. On the east, Turtle, Ochre, Vermilion, Wilson and Valley rivers pour their waters into Lake Dauphin, flowing across the fertile plain south and west of this lake. Fork, Pine and Duck rivers flow from the face of Duck Mountain, the former into Mossy River and the latter into Lake Winnipegosis.

Drainage

General physical features.

In its general physical features it presents very great diversity of character. The mountains, or rather the one mountain cut in twain by the great depression of Valley River, cross the country in a north-north-westerly direction, forming a high, rugged ridge rising in different places from thirteen to nineteen hundred feet above Lake Winni-

pegosis. To the eastward these mountains descend in a steep, wooded slope to an even, almost unbroken, alluvial plain, which inclines gently to the lake shore. Westward it descends much more gradually, and, except in the vicinity of lat. 51° 30′, without any abrupt escarpment, towards the Plains.

Over a great portion of the higher lands, the surface is dotted with beautiful little lakes of clear, fresh water, those in the more open country being encircled with green wreaths of small poplar and willow, while in the more thickly wooded tracts in the higher parts of the mountains, tall spruces are growing to the edge of the water. Many of these lakes are drained by permanent brooks, but most of the smaller ones are isolated during the greater part of the time, and overflow only in rainy seasons or when the water is at its highest stages. They are all of glacial origin, lying in the depressions of the irregular surface of the till or unstratified glacial deposits. **Many small lakes.**

The whole land surface is more or less thickly timbered, the woods varying, however, from a few scattered clumps of willows in the townships in the south-west corner of the map, through groves of poplar severed by open glades in the country bordering the Assiniboine, to coniferous forest on the summit and northern and eastern flanks of the mountains. In the valley of Swan River, and in the tract of country south-west of Lake Dauphin, the forest again gives place to a partly wooded country, the open areas of which are often covered with a luxuriant growth of rose bushes and other small shrubs. **Timber.**

Lake Dauphin is a shallow body of water twenty-eight miles long and ten to twelve miles wide, with an approximate elevation above the sea of eight hundred and forty feet. Mossy River flows from its northern end into the south-west angle of Lake Winnipegosis. Its shores, where seen along its southern boundary, were either low and marshy, or bordered by beach-ridges of well-rounded limestone gravel, behind which stretched extensive meadows of rich, tall grass. In high water these meadows are doubtless flooded, but at present they are quite dry, and will be so in all ordinary seasons. Behind these meadows, a wide and apparently flat plain stretches back to the foot of the Riding Mountain. Instead of being level, however, it rises gradually and regularly, being generally well drained by the numerous small clear streams that flow through it in narrow, winding channels. These streams are skirted with rows or narrow belts of timber consisting of elm, oak, birch, and cottonwood. Between these wooded belts, the plain is dotted with groves of poplar and willow. The soil is a rich alluvial clay loam, on which abundant crops of wheat, oats, barley, maize, as well as all the ordinary garden produce grown in eastern Canada and the central and eastern United States, can be raised. On the **Lake Dauphin.** **Rich alluvial plain.**

third of August, 1887, barley was ripe and being cut, and the fields of wheat were quite tinged with yellow. On the 17th of August the settlers were reaping the dead ripe wheat, which gave promise of a very heavy yield.

Absence of summer frosts.

The summer frosts, too, which have occasionally proved prejudicial to the crops in some parts of Manitoba and the North-West Territory, appear to avoid this favoured district. This is, no doubt, in part due to the slope of the surface, the cold air sinking down the gentle incline till it reaches the lake, where it is warmed by radiation from the surface of the large body of water which has been warmed by the hot sun of the day before, and which, on account of its shallowness, gives out its heat rapidly to the overlying air. The great luxuriance of the grasses and herbage in this district has also much effect in hindering the occurrence of summer frosts. By increasing the amount of water evaporated in the day time it renders latent a large amount of heat, which again becomes sensible when this moisture is deposited in the evening in the form of dew. Growing grain would also have precisely the same effect. Its sheltered position is also very much in its favour. A wind blowing from the east across the great lakes of the Winnipeg basin will be loaded with moisture, which, if it does not fall as rain, will form into clouds or be deposited as a heavy dew, and will avert a frost either by hindering the radiation of the heat from the lower stratum of air, or by raising its temperature. If the wind is blowing from the drier plains to the west it will be partly diverted to the south-west along the Duck and Riding mountains, and what crosses the mountains, though very dry, will be so much warmed by condensation in descending thirteen to eighteen hundred feet that little danger of frost need be feared from it. In this connection, it may be remarked that it appears very probable that the planting of trees around the fields on the plains of Manitoba and the North-West Territory would have considerable influence in preventing the occurrence of summer frosts by breaking the winds and hindering the free circulation of air. The moisture that was evaporated from a field of growing or ripening grain or other crop would then, to a considerable extent, remain over the field, whereas now it is often replaced by dry air from the plains, which offers no obstruction to the rapid loss of heat from the earth by radiation. The circumstances under which frost occurs are often as follows:—During the day a stiff wind is blowing from a westerly direction, carrying off the moisture as fast as it is evaporated. In the evening the weather becomes very calm, and on account of the absence of any moisture in the atmosphere the stars shine with exceptional brilliancy. The earth is warm from the heat of the day, but radiation

Reasons.

Luxuriance of herbage.

Sheltered position.

Presence of trees.

proceeds so fast that by one or two o'clock in the morning its immediately available supply of heat is exhausted and the overlying air falls below the freezing point. The presence of a greater amount of moisture in the air will prevent this rapid dissipation of heat, and one of the means of insuring the presence of this moisture is by constructing wind-breaks in the form of rows of trees in order to retain the damp atmosphere over the fields rather than to allow it to be replaced by the drier air of the plains.

Smudges, the smoke from which on those quiet, bright nights will settle down over the land, would doubtless also have a very beneficial effect in hindering the occurrence of frosts.

Breaking of the soil.

The breaking up and tilling of the soil will also have a great effect in reducing the diurnal variations of temperature. The direct rays of the sun during the day do not raise the temperature of ploughed land as high as that of the unbroken plains, but they warm it to a greater depth, a fact which may readily be observed in walking across the drier plains on a hot day in summer. The dry sod, covered with short withered grass, will be felt to be very hot, but if ploughed land is reached, the ground will at once be found to be much cooler. By taking a spadeful of earth from the two places the lower part below the sod will be found to be very much cooler than that under the ploughed land. The effect that this will have on the night temperature of the air will be that the radiation of heat from the ploughed land will be much slower than from that which is unbroken, but which is practically bare on account of the withering of the short grass. The temperature will be lowered comparatively slowly, and while in the latter case a frost might have set in at four or five o'clock in the morning, in the former the air will be kept above freezing point till the sun rises again.

Old shore lines of Lake Agassiz.

But to return to the alluvial Lake Dauphin plain, the surface is so level or evenly sloping that lakes or ponds are very scarce, but plenty of good water can easily be obtained in wells ten to fourteen feet deep. In ascending from the lake to Riding Mountain, the surface rises by low steps to the foot of the more abrupt escarpment. The steps are occasionally replaced by ridges of rounded gravel, both the steps and ridges representing old shore lines of the ancient lake which formerly occupied the whole of the basin of Lake Winnipeg and the valley of the Red River, a lake the former existence of which was first clearly pointed ont by Prof. H. Y. Hind in 1859 and which was afterwards named by the late General Warren, Lake Agassiz, in honour of Louis Agassiz, the first great exponent on this continent of the force of glacial erosion and of the former distribution over the northern portion of America of a great ice-sheet in glacial times. The full comparison of these ancient shore lines with the shores of the present adjoining lakes must be left to the final report on this area.

Most of the steps are low, seldom reaching a greater height than ten or twelve feet, but one of the higher ones, which is crossed on the Vermilion River trail, and the bottom of which may be considered the foot of the mountain, rises to the height of one hundred feet. Its face is now a steep slope wooded with poplar and small bushes, but when the waves of the ancient lake beat against it, it rose above the water as a naked cliff of white Cretaceous chalk-marl. Following the shore-lines northward to beyond the Valley River, the low coast-cliffs almost entirely disappear, and the ancient shores are represented entirely by gravel beach-ridges. This change of conditions is caused by the fact that the base of the escarpment of Duck Mountain is much higher than the foot of Riding Mountain, and higher than the highest level to which Lake Agassiz appears to have risen. From this escarpment the land slopes gently down a long easy grade to the level of Lake Winnipegosis.

Ancient coast-cliff.

Gravel beaches.

The beaches consist of more or less rounded gravel, the pebbles, which are chiefly of limestone, though a few are of granite, varying from the size of pigeons' eggs down to that of No. 6 shot, but however fine, they are still distinct pebbles, mixed with little or no quartz sand. The ridges follow in a long sweeping curve the general direction of the face of the escarpment. The highest of these ridges seen on Shanty Creek has an elevation of 1,365 feet above the sea, and as far as one could judge is about two hundred feet below the level of the base of the mountain escarpment. The pebbles in it have their angles worn off by water action, but are not at all well rounded, and between it and the next lower ridge there is very little alluvial deposit, showing that the water stood at this height for a, comparatively, very short time. Above the ridge the surface is lightly undulating and composed entirely of unstratified glacial till scattered over with irregular pebbles and boulders, it having never been buried under the waters of this great post-glacial lake.

Natural roads.

The northward extensions of these ridges form remarkably straight natural roads through the otherwise level and often swampy or marshy country. One, having an elevation of 1,084 feet at Valley River, was followed northward with buckboard and carts for twenty-three miles, to beyond Shanty Creek, while another, about seventy feet above the last, was followed from a little south of Wilson River northward for twelve miles to a branch of Valley River, where the extension of the forest across the ridge obliged us to descend to its lower neighbor. At Shanty Creek we returned to the higher beach, and continued to follow it northward for nineteen miles, at which point it was still quite well marked. Half a mile to the eastward the lower beach was also typically developed. Thus these two ridges were found to extend, the lower one at least forty, and the upper one forty-four miles.

A few miles further north, near Duck River, similar gravel ridges are found to obtain, though here, instead of being generally open and grassy, they are covered in part with a scattered growth of small Banksian pines. Looking southward from Duck River along a ridge, the height of which is given on the profile of the old location of the Canadian Pacific as 1,201 feet, a high knoll is seen to rise above and just to the westward of it. This knoll, when reached, was found to be the northern end of a gravel ridge running off to the southward, and rising sixty feet above the ridge immediately to the east of it. Its face is steep, the slope being apparently as great as that at which the gravel would stand. The point is bent around to the westward in the form of a knob or hook, the whole appearing as if it had projected out into the lake as a gravel spit or hook, as the land behind as well as in front of it is from fifty to sixty feet below its summit.

Beaches pine-covered.

End of beach.

This point was somewhat peculiar in being scattered over with a great number of large gneissoid boulders, lying on a surface of sand filled with rounded, waterworn pebbles of gneiss, limestone, ironstone, etc. As a rule, the ancient beaches are composed entirely of small rounded pebbles, in this particular differing very materially from the beaches of the lakes which now occupy the lower levels of the Winnipeg basin. On the existing lakes the shores are very thickly strewn with gneissoid boulders, which in winter have been, and are still being, frozen into the ice, and then shoved outwards by its expansion till they are placed up beyond its reach, or packed into a very regular wall. Many of the boulders on the above mentioned ancient gravel bar or spit have probably been placed there in a similar way, the bay to the westward having doubtless been frozen over during the winter, while the general absence of boulders on the long straight beaches would seem to indicate that the whole lake was never covered with ice.

Gneiss boulders

North of Duck River the higher ridges, which alone have been followed here, bend sharply round the north-east corner of the Duck Mountain into the valley of Swan River.

Abrupt change of direction.

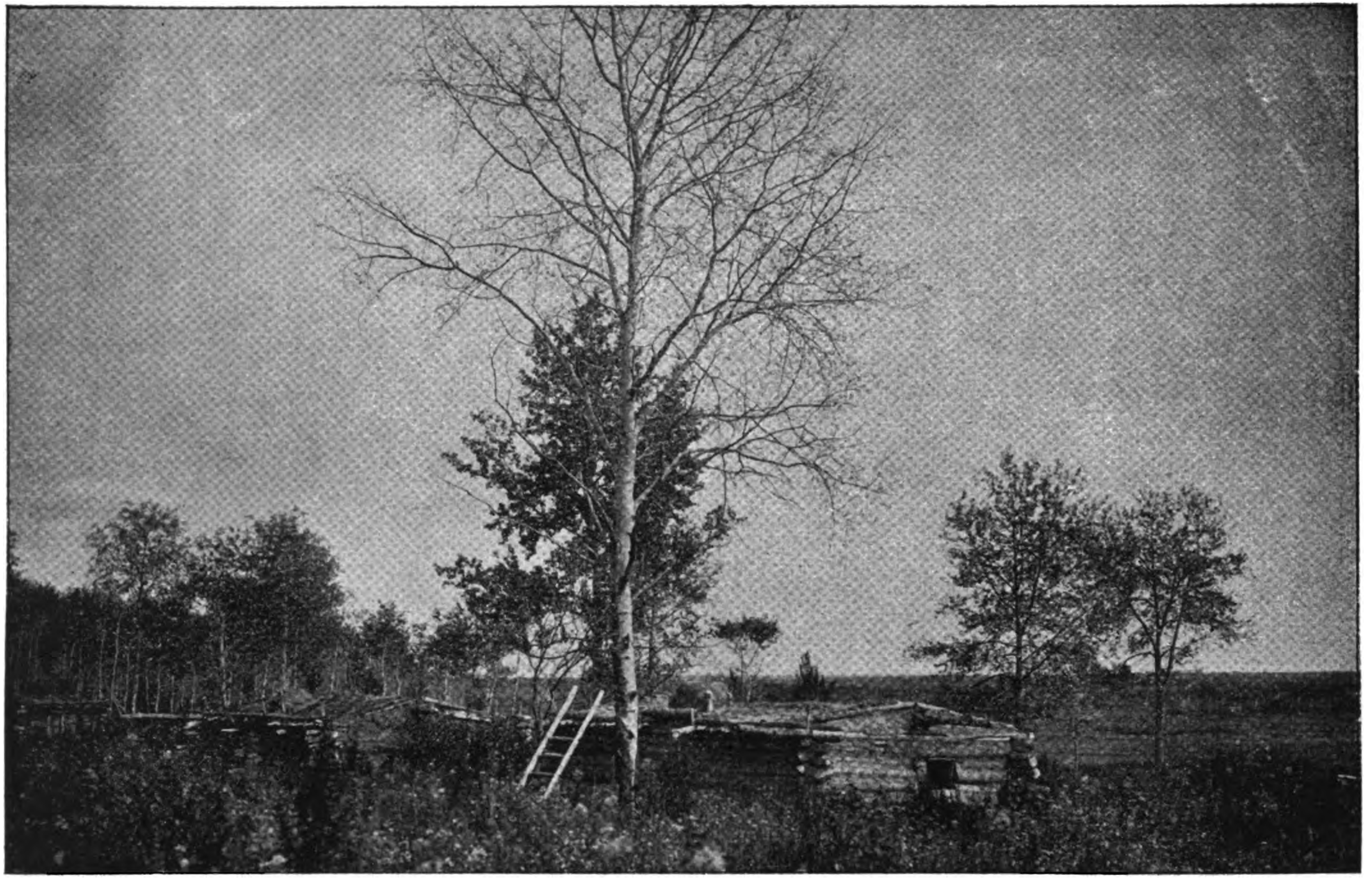
The presence of these ridges influences in a very marked degree the character of the country they traverse. Although they furnish magnificent natural highways they also act as dams in preventing the ready drainage of the country down its easy natural slope, except in a few places where these dams are broken through by streams such as the Duck and Fork rivers. There is very commonly a marsh or marshy lake just above or west of the ridge, or a little sluggish stream may flow northward or southward beside it. The country in the latter case is somewhat better drained and generally supports a close growth of small black spruce and tamarac. The lower side of the ridge is drier and sometimes supports a growth of poplar, but

Ridges serve as natural dams.

generally is thickly covered with small black spruce. Some fine groves of large white spruce are met with close to the banks of the larger streams. Stunted oaks on the ridges in the more open parts and some beautiful groves of tall, stately elms were seen, a very noticeable one of the latter being a grove near the foot of the Duck Mountain, a few miles south of Duck River. A few pleasant prairies here and there occur, but they are not numerous, and the country may be said to be generally thickly wooded. Forest fires in recent years have, however, destroyed the greater part of the timber that could have been converted into lumber, and instead there is now a close growth of small sticks as yet comparatively valueless. As was stated above, large areas are now covered with swamp or marsh, but this wet land could be drained with very little difficulty, since the surface everywhere slopes gently towards the east, except where the incline is broken by gravel ridges from fifty to one hundred and fifty yards in breadth. Drains could be readily cut through these at intervals sufficiently close to allow the water to flow off freely to the lake.

Valley river. Of the two largest streams that flow eastward within the district, the Valley River winds in a beautiful sloping valley which doubtless represents an ancient drainage channel in pre-glacial times. Above or west of the gravel ridges that cross this valley is a wide sandy plain, representing an old delta deposit when Lake Agassiz was at its highest stages and when a stream flowed into it through the valley of Short Creek from the west side of the Duck Mountain. **Swan river.** The Swan River valley is much wider and is cut down to a much greater extent. The lower part, below what is locally known as the "Coast Ridge," is covered with alluvial deposits of sand or sandy clay, while further west are some rough morainic tracts, among which lie extensive flood plain deposits. In both of these valleys, Indians and Metis have at different times had thriving little villages, the soil being very rich and fertile. On the latter there is now a Metis settlement about a mile or two beyond the northern limit of the present map. Two Indian reserves were formerly occupied on the banks of this river and on them the Indians raised grain and the ordinary root crops. Lately, these Indians have been removed to the vicinity of Fort Pelly for the greater convenience of communication and trade.

Old Indian settlement. On Valley River there was formerly an Indian settlement in township 25, range 24, west, and now there is a thriving village at the mouth of Short Creek, at the point where the River leaves the Duck Mountain. A good cart-trail runs from Russell on the Manitoba and North-Western Railway to this village, and carts can also pass eastward from it to the Lake Dauphin settlement. Here in the summer of 1887 some good crops of the ordinary grains and roots were being raised.



J. B. TYRRELL, PHOTO., 19TH AUG., 1887. G. E. DESBARATS & SON, ENGRAVERS & PRINTERS, MONTREAL.

OLD INDIAN HOUSES, NEAR VALLEY RIVER.
Township 25, Range 24 West Manitoba.

West and south-west of the alluvial plain of the ancient Lake Agassiz, the Duck and Riding mountains rise to from two thousand to two thousand seven hundred feet above the sea, in most places faced by a steep escarpment, but between Vermilion and Valley rivers the slope is gradual, no appreciable escarpment being seen during the ascent. This slope is generally well drained and in places supports a strong growth of poplar and spruce, but unfortunately much of it is fire-killed and useless. Duck and Riding mountains.

The higher parts of the mountains are very rough and uneven, being composed of drift hills and ridges from one to three or four hundred feet high, among which nestle beautiful lakes of pure clear water, or sparkling brooks flow to the main watercourses, most of which have a general north or south direction. Many of the hills are thickly clothed with spruce and balsam fir (A. balsamia) mixed with birch and poplar, and in the more southern portions with maple (Acer spicatum) and more northerly with an occasional tree of mountain ash. Some of the knolls in the northern and north-eastern areas are so thickly strewn with large gneissoid boulders, that the land is almost barren, supporting but a short stunted growth of Banksian pines, and where these have been burned, as they have been over considerable areas, the ground is almost entirely uncovered by either grass or herbage of any kind. Between these rough hills stretch considerable areas of level swampy country covered with a close growth of black spruce, in most cases too small to be of any general economic importance. Rough morainic country.

The northern face of the Duck Mountain has formerly supported much excellent forest, but most of this area has now been burnt over, and is being overgrown with poplar. A fine grove of white spruce however yet remains near the head of Favell River and between Favell and Rolling rivers. Some spruce.

The thickly wooded areas of these mountains are the favourite hunting grounds of Indians who have their reserves by the lakes or along the Assiniboine. One of these latter bands, under Chief Coté, has cut a good cart trail from its reserve north of Little-Boggy Creek to Angling Lake, where it has built a number of substantial log houses. These houses are deserted during the summer, but in the autumn, when the season for hunting and trapping returns, a portion, if not the whole, of the band moves here from the village and farms on the Reserve and supports itself during the winter on the proceeds of the chase. Good hunting grounds.

West of Duck Mountain stretches away to the westward the rich alluvial plain through which the Assiniboine River flows in a direction 25° east of south. The eastern side of this plain between Lac la Course and Little-Boggy Creek is a steep slope or escarpment from two to five Assiniboine valley.

hundred feet high, but south of Little-Boggy Creek this escarpment soon disappears, and the plain rises through a gradual though generally undulating or rolling, incline to the summit of the mountains. The soil in this plain or valley bottom is exceedingly fertile, being composed of a rich alluvial dark sandy loam, which produces abundant crops of grain.

Its peculiar character.

The course of the river itself is a very peculiar one. Just above Fort Pelly it flows in an almost northerly direction, making straight for the wide valley at the bottom of which at present a small stream, Shake Creek, rises in a quagmire just north of the Fort and flows into Swan River. Instead of following this valley northward, however, the Assiniboine turns abruptly and flows a little east of South in the bottom of a shallow and indefinite valley. This valley, however, gradually becomes better defined and increases in depth lower down, and though the country on either hand becomes higher, the river maintains its direction, at length cutting a valley about four hundred feet deep. The land on either side of the valley north of the mouth of Shell River consists of alluvial deposits which appear to have been laid down in the bottom of an ançient lake which stretched westward from the western base of the Duck Mountains. Its further shore has not yet been determined.

Lake Assiniboine.

This lake, as well as Lake Agassiz, is closely associated with the former glacial conditions of the country, and a brief statement of the conditions then probably existing may be here given.

Conditions during glacial period.

During the continuance of the glacial period, a huge glacier moved in a south-south-easterly direction in the great valley east of the Duck, Riding and Pembina escarpment, while another flowed parallel to it down the valley of the Assiniboine on the western side of these mountains. At times these glaciers doubtless coalesced into one vast ice sheet, while at other times they were separated by the mountains either in part or entirely and along the tops of the mountains threw up a median, or rather what has been called by Professor Chamberlin an "interlobate" moraine consisting almost entirely of boulders and debris of the Archæan rocks to the north. This is what has given the mountains their rough, rugged and broken character, a character which is most pronounced in the more northern portions. Where the Indian trail crosses the north-eastern corner of the Duck Mountains much of the country is so completely a mass of boulders that it supports but a few small stunted Banksian pines. At length a rise of the land took place in the southern or central portion of the continent, which rise is doubtless accountable in part for the high elevation of some of the plateaux of the Western states and of the Rocky Mountains.

The glaciers now rapidly receded down the valleys, leaving large bodies of fresh water occupying the depressions along their fronts. It was apparently in this way that Lake Agassiz, the ancient lake of the Red River valley, and the lake which occupied the upper part of the Assiniboine valley, were originated. The ice front at last receded to a point where it again became relatively stationary, the flow of ice from the higher lands making up for the portions that were being melted off and carried away. Recession of the glacier.

Whether this ice front formed the northern or north-eastern shore of the above-named lakes it is impossible as yet to say, but the fact that the old shore lines of Lake Agassiz rise by a very gradual and even incline to the north as far as they have as yet been traced, showing a northern elevation of the land since the lake stood at its higher level, rather than a very considerable northern depression or southern elevation of the land, which must have occurred if the northern border of the lake was any of the land lying to the northward, lends great strength to this theory. However, for the complete determination of this question, further systematic investigation is necessary, but the existence of the lakes themselves admits of no doubt whatever. The relation of the two lakes to each other is somewhat difficult to make out completely, having doubtless been quite different at different times. At one time Lake Assiniboine was possibly only a bay of Lake Agassiz, being perhaps connected with it through the valley of Swan River, but if this was the case the alluvial deposits in the upper part of the Swan River have been covered by succeeding glacial deposits. At all events at one time a glacial dam appears to have stretched across the north end of this portion of the Assiniboine valley, and the superfluous waters of Lake Assiniboine flowed into Lake Agassiz through the deep valley which is now in part dry, and in part drained by Short Creek into Valley River. It was at this period that the delta plains of the Valley River were formed. When Lake Assiniboine receded towards the north a considerable stream still flowed through the valley of Shell River, fed in all probability by local glaciers on the Duck Mountain, while other streams flowed in from the south in the lower part of the same valley, and in a deep valley to the east of it now abandoned. After this time the valley of Snake Creek was formed and Lake Assiniboine was doubtless drained. The glaciers on the mountains, however, now gradually extended, closing all these valleys and the water from the ice front was obliged to find some other outlet, which it did down the valley of the Assiniboine below the mouth of Shell River, this valley having in all probability been first marked out, in part at least, by a stream flowing from the foot of Riding Mountain northward into Lake Assiniboine. These glaciers have left marks of their presence in

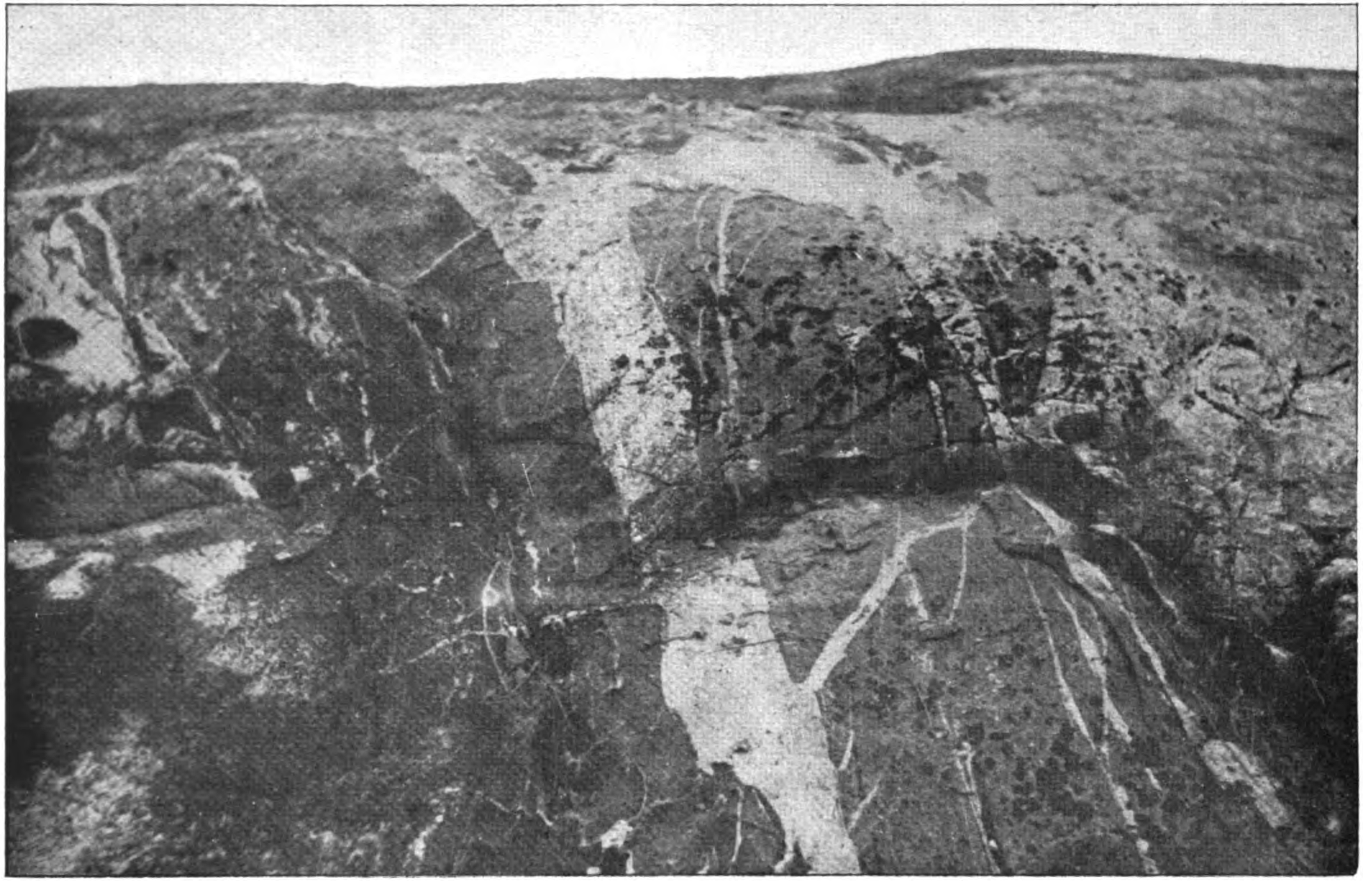
Gradual incline of beaches.

Valley of Short Creek.

Recedence of glaciers.

Moraines. morainic dams stretched across the valleys of Short Creek, Shell River and Snake Creek, &c. The flow of water was thus established towards the south, and a valley was worn out through which the Assiniboine River continues to flow up to the present time, though it is probable that now the amount of sediment carried away by the river exceeds by very little, if it exceeds at all, the amount of sediment brought down into it by small affluent streams, and consequently it has ceased to deepen its valley.

The geological structure of the country will be discussed in the final report, but it may be here stated that the floor underlying the whole country is a white or cream-colored Devonian limestone. Its surface is somewhat undulating, but on the whole it exhibits a slight slope towards the west or south-west. On this floor are heaped up successive beds of sands, marls and shales of Cretaceous age, constituting all the older rocks seen in this area west of the lakes. These form, under the glacial deposits, the entire mass of the Duck and Riding Mountains, and extend from them westward across the Assiniboine and under the Great Plains to the foot of the Rocky Mountains.



A. C. LAWSON, PHOTO., 1886. G. E. DESBARATS & SON, ENGRAVERS & PRINTERS, MONTREAL.

Contact of Laurentian gneiss and schists of the Coutchiching series, on island between Gash Point and Back Point, Rainy Lake. The gneiss (light colored portion) penetrates the schists in all directions. It extends away continuously to the right, while the schists (shaded portion) extend to the left.

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA.

ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR.

REPORT

ON THE GEOLOGY

OF THE

RAINY LAKE REGION.

BY

ANDREW C. LAWSON, M.A., PH.D.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

MONTREAL:
DAWSON BROTHERS.
1888.

To A. R. C. SELYWN, C.M.G., LL.D., F.R.S.

Director of the Geological and Natural History Survey of Canada.

SIR,—I herewith submit to you my report upon the physical and geological features, and economic resources of portions of the Rainy Lake and the Lake of the Woods regions, including the country through which the Rainy River flows; also a geological map of the same, in two sheets, on a scale of $\frac{1}{4}$ of an inch to the mile; each sheet embracing an area of 72×48 miles. The topographical surveys necessary for the construction of the map, upon which to represent the geology, occupied a much larger portion of the time devoted to field work than did the geological examination. With the exception of Rainy River, all the topography on the Canadian side, in the Rainy Lake sheet, is from our own surveys, checked by a few exploratory lines that had previously been run through the country.

Our warmest thanks are due to Mr. and Mrs. Pither of the Indian Agency at Coutchiching, for their most generous hospitality to myself and party during the seasons we have been at work in the country around Rainy Lake.

I have the honor to be,

Sir,

Your obedient servant,

OTTAWA, March 4, 1888. ANDREW C. LAWSON.

NOTE.—Bearings have reference to the true meridian, and read from 0° (N.) around to 360°.

REPORT

ON THE GEOLOGY OF THE

RAINY LAKE REGION.

INTRODUCTION.

Progress of survey.

The present report, with the accompanying geological maps, is an instalment of the results which are accruing from the systematic prosecution of a topographical survey and geological investigation of country north-west of Lake Superior. The northern portion of the Lake of the Woods was first surveyed and the results published in the Annual Report, Volume I, 1885. In continuation of this work, Rainy Lake and the region adjacent to it were, in 1885, next subjected to survey, as promising the most satisfactory results on account of their accessibility, and the abundance of rock exposures. Of the two sheets now ready for publication, the one embracing the Rainy Lake Region, or the "Rainy Lake sheet," is the more interesting and important. The other or "Rainy River Sheet," embracing the greater part of the Rainy River and the Lake of the Woods, from about the latitude of Turtle Portage and Driftwood Point southward, is much less satisfactory, and represents much less work, from the fact that only a portion of it is within Canadian territory; and of that the greater part is covered either by the waters of the Lake of the Woods or by the post-glacial deposits through which the Rainy River flows. In 1885, I was assisted by Messrs. A. E. Barlow, W. H. Smith and C. S. Morton. These gentlemen were engaged till the close of the season in the prosecution of topographical surveys of portions of Rainy Lake and of the Kishkutena canoe route, while my own work consisted of a geological reconnaissance of the whole field, as sketched briefly in my summary report for that year. A portion of the season was also devoted to the survey of those islands of the Lake of the Woods which come within the Rainy River sheet.

Maps.

Field work in 1885.

Field work in 1886.

In 1886, I was assisted in the field by Mr. W. H. Smith. The season's operations were begun at Wabigoon, where Mr. Smith was instructed to carry a micrometer and compass survey from a fixed point on the Ca-

Manitou route. nadian Pacific Railway through to Rainy Lake, by way of the Manitou canoe route, to connect with the system of township surveys on Rainy River. The west side of the lakes on this route was mapped in detail as far as the middle of Manitou Lake, from which point onwards both sides were embraced in the survey, being within the limits of the Rainy Lake sheet. Several weeks were next occupied by Mr. Smith in completing the survey of the north western expanse of Rainy Lake from Coutchiching northward to the Devil's Cascade. In addition to the usual micrometer and compass survey, a transit line was run between the two latter points, as a basis upon which to check the variation of the compass, which does not appear to be uniform throughout the district. This done, Mr. Smith next made a survey of an important chain of lakes extending from the bottom of Redgut Bay, Rainy Lake, to Lake Manitou, which it is believed has never hitherto been explored. During the last few weeks of the season, Mr. Smith was engaged in completing certain detached surveys near the mouth of Rainy River and in the south part of the Lake of the Woods, which stress of weather or other adverse circumstances had interfered with the previous season; so that nearly all the topographical material requisite for the mapping of the Rainy River sheet was secured.

Rainy Lake.

Otukamamoan route.

Lake of the Woods.

After having, at the beginning of the season, provided Mr. Smith with men and equipment requisite for his survey of the Manitou route, I left him at Wabigoon and proceeded to Rat Portage. Here two or three days were spent in the usual preliminary arrangements, and in inquiring into the state of the mining industry of the district, after which I proceeded to make a topographical and geological survey of the canoe route which extends from Lake of the Woods to Rainy Lake *via* Crow Lake and Pipestone Lake. The route consists of a chain of large lakes which have never hitherto been mapped. The west side of Crow Lake had previously been traversed by the survey; so that the work was begun in the neighborhood of Turtle Portage, and carried along the south side of Crow Lake; thence through Boulder, Sand-hill and Schist Lakes into Pipestone Lake, and then through Stonedam, Loon, Jackfish and Footprint lakes to the North-west Bay of Rainy Lake. The survey was made by means of a Massey's patent log, the portages being chained, and was checked at various points on previous surveys.

Pipestone route.

Geological work.

The belt of Keewatin rocks which crosses the Kishkutena route between Lake Kishkutena and Lake Despair was studied in detail, and traced in continuous connection with the area of the same rocks examined earlier in the summer on Crow Lake and Pipestone Lake. Some three or four lakes, of which Kahtimiagamak Lake is the most important, were surveyed, and added to the topography of the route. The

geological features of the northern part of the Manitou route were mapped by the aid of the topographical sheets supplied by Mr. Smith's survey. I returned to Rainy Lake by the Little Canoe route, making a log survey of the several lakes which form it, and mapping the geological features exposed on their shores.

In the southern part of Rainy Lake, some time was spent in working out the geological features of the islands and part of the south shore, as well as of those portions of the north shore which required special investigation in the light of the previous season's work; and considerable additions were made to the topography.

Pigeon River route. For the purpose of acquiring a knowledge of the geological features of the south-eastward continuation of the Rainy Lake formations, and at the same time of becoming familiar, in a general way, with the features of the country between Rainy Lake and Thunder Bay, the last few weeks of the season were devoted to an examination of the shores of the canoe route along the Canadian side of the Minnesota boundary, and the field work was brought to a close at Port Arthur.

Field work in 1887. In 1887, I was again assisted by Mr. W. H. Smith. More than half of the season, till about the middle of August, was required for the completion of the surveys and examinations necessary for the construction of the Rainy Lake sheet. My own work comprised: a further examination of a few critical points on the Kishkutena and Pipestone routes, with some slight additions to the topography; a survey and examination of Yoke, Strawberry, Bluff, Sucker, Furlonge, and Kaiarskons Lake; of the lakes of the Lake Harris route, within the limits of the sheet; of the lakes of Big Canoe River route; a geological examination of portions of Rainy Lake not previously examined; a geological examination of the Otukamamoan route, with additions to the topography, and an examination of the formations of Rainy River and the south part of the Lake of the Woods, together with a portion of Sabaskong Bay.

Mr. Smith's time was taken up with an exploration of the country between Big Turtle Lake and Heron Lake, resulting in a survey of a number of lakes; a survey of the lower part of the Little Turtle River, of the lakes of the Little Kishkutena route, and of the route between Stanjikoming and the North-west Bays; and more especially of the shore and islands of the east arm of Rainy Lake.

Character of country and methods of survey. These various surveys and examinations, occupying our time up to about the middle of August, completed all the work that was deemed necessary for these two sheets, and our field of operations was moved further east. The country is devoid of roads or trails, and accessible only by the net-work of lakes, rivers and canoe portages, which is spread over its surface. All our travel was, therefore, effected by

means of canoes, with occasional excursions on foot through the woods. The surveys were such as enabled us to work rapidly and yet to afford sufficiently accurate data for the geological elucidation of the region and its cartographical representation on the scale adopted. Measurements on shore lines were made by the micrometer telescope or the Massey log, together with a compass triangulation having the lines so measured from point to point as bases. Portages or bush traverses were measured by the tape or by pacing. All bearings were made with reference to the magnetic meridian by means of the prismatic compass, except on a check line from Coutchiching to the Devil's Cascade on Rainy Lake where the transit was used.

Previous surveys.

The following surveys and sketches which had been made prior to ours, have served as checks and aids to our work, on the Rainy Lake sheet:

The Dominion Lands Rainy River Township Survey.

The Minnesota township surveys along the south side of the International boundary.

The Canadian Pacific Ry. exploratory line from Wabigoon to Coutchiching through the Manitou canoe route by Mr. W. Kirkpatrick.

A similar exploratory line from the Canadian Pacific Ry. to Rainy Lake by the Sand Island River route.

The Canadian Pacific Ry. exploratory line from White-fish Lake to Heron Lake.

The Indian Reserve surveys.

The timber limit surveys were of little service, and in some instances were ignored in our compilation.

The sketches of Thompson's Boundary survey have been superseded by our own, except for a few miles of the south-east side of Redgut Bay where his sketch was adopted.

A transit and chain line by Mr. Saeger, from the Indian Reserve at Wabigoon down the Manitou route to about half way to Fort Frances, was kindly placed at my disposal by that gentleman, and has also been used as a check.

For the Rainy River sheet, the surveys and sketches at our disposal in addition to our own, were :—

The Dominion Lands Rainy River township surveys.

C. F. Miles' survey of Sabaskong Bay for the Department of the Interior, 1875.

Joint maps of the North American Boundary Commission, 1878.

Cartographical work.

In the cartographical work we have had the advice and assistance of Mr. Scott Barlow, chief draftsman, who has laid down the projection of the sheets, and determined, as nearly as possible, the position of the more important points. The general compilation and drafting of the

Rainy Lake sheet has been the work of Mr. W. H. Smith; while the Rainy River sheet is by Mr. A. E. Barlow.

Geologically, the Rainy River region has hitherto been almost a *terra incognita*. The literature of the field is very scanty, and has reference only to the shores of Rainy Lake itself.

Previous geological work Literature.

Bigsby.

Dr. J. J. Bigsby has the honor of being the first to attempt a geological description of Rainy Lake. In the Quarterly Journal of the Geological Society of London, for Jan., 1854, Vol. X, he published a paper on the "Geology of Rainy Lake, South Hudson's Bay," accompanied by a geological map of the lake on a scale of four geographical miles to the inch. In his paper on the "Erratics of Canada," in the same journal for April, 1851, Dr. Bigsby's notes, so far as they apply to Rainy Lake, are interesting, and indicate a considerable amount of attention to superficial phenomena.

Owen.

In the Report of the Geological Survey of Wisconsin, Iowa, and Minnesota, by D. D. Owen, 1852, there is a paragraph on page 319 devoted to brief notes of the rocks observed on a two days voyage through the lake from Kettle Falls to Rainy River.

Bell.

In the Report of Progress of the Geological Survey of Canada for 1873, Dr. Bell in his "Notes on the Geology of the Region between Lake Superior and Red River," devotes about a page (88-89) to notes of geological observations made in passing through Rainy Lake and down Rainy River.

Hind.

In the "Report on the exploration of the country between Lake Superior and the Red River settlement," 1858, Prof. H. Y. Hind has a chapter devoted to a description of Rainy Lake and river. The most interesting of his notes from a geological standpoint are those descriptive of Rainy River. No attempt is made to add to Dr. Bigsby's description of the geology of the lake.

Hector.

Hector, in his paper "On the Geology of the Country between Lake Superior and the Pacific Ocean," Q. J. G. S., Vol. XVII, has a brief reference to the geology of Rainy Lake.

Dawson.

The literature bearing on the geology of the south part of the Lake of the Woods has already been cited in my report for 1885. The "Geology and Resources of the 49th Parallel" by Dr. G. M. Dawson gives an account of the southern portion of the lake, particularly the United States side, which my own notes on the Canadian side, where rock surfaces are more abundant, will serve to supplement.

Physical Features—their Dependence upon Geological Conditions.

Surface of country.

The surface of the country mapped on the two sheets accompanying this report presents a natural division into two portions, the respective characters of which are in striking contrast. These are :—

1. *The rocky lake country.*
2. *The alluvial plain, or river country.*

Alluvial plain.

The latter differs from the former essentially in the fact that the rocky, hummocky surface, the depressions of which would naturally form lake basins, is covered by a thick, uniformly spread blanket of post-glacial deposits. The surface of these deposits forms a comparatively flat, well wooded plain; and on the United States side, across northern Minnesota, this plain appears to merge into the prairie country. On the surface of the plain there are almost no lakes, the undrained water accumulating in wooded or treeless "muskegs." Drainage is effected by rivers of the usual sort, which cut their way through the soft horizontal strata so as to form shallow cañons.

Rocky lake country.

The rocky lake country presents the character of a plateau which, regarded on the large scale, is remarkably flat and devoid of prominent elevations, although the surface, in detail, is extremely uneven and hummocky or mammilated. It presents, for the most part, the glaciated surface of the rocks, either quite bare or covered only by forests and forest loam. There is a marked absence of alluvium or fine drift, except in occasional patches and small areas. The plateau abounds in lakes which lie in rocky basins. Rivers are few and short, being mostly mere connecting links or series of rapids between lake basins. Rivers of the cañon type can scarcely be said to occur at all, except, as in the case of the Big Turtle River, a small area of soft, flat-lying strata, through which it flows, presents the conditions which determine its character as such locally. These being the broad distinctions between the surface aspects of the two portions into which the region under consideration is divided, we may proceed to consider each portion somewhat more in detail.

The Rocky Lake Country.

Characteristic feature.

The feature of this portion of our field which is of most prominence and interest, is that of the lakes. In my report of 1885, I have drawn attention to some of the more salient characteristics of the Lake of the Woods, and shall, therefore, not now refer to it again, although portions of it fall within the field under consideration. I shall attempt, by a reference to Rainy Lake, and to the chains of lakes tributary to it, to point out briefly the close relationship which exists between geo-

logical conditions and topographical contour. A glance at the map shews that Rainy Lake is a receiving basin or reservoir for the drainage of an extensive circle of country. At its south-west corner the waters of the lake are dammed back by a low escarpment of post-glacial clays, save for the gap where this formation has been cut through, and the waters of the lake break over the jagged upturned edges of an underlying ridge of schists, forming the Coutchiching rapids, the beginning of Rainy River. To the N.N.W.,N., N.E., E. and S.E. of the lake, the surface of the country rises very gradually, forming an amphitheatre-like slope, upon the various stages of which lie lakes linked in chains, or linear series, which converge upon the receiving basins. This slope, although distinctly recognizable as such, by following the drainage of the lakes from stage to stage, has a very slight incline, and is practically, as before stated, a plateau. The average slope can at most be but a few feet in the mile, but the figures are difficult to arrive at, on account of the rough, uneven character of the surface, and the absence of systematic levels. The drop from Lake Manitou to Rainy Lake was estimated by Mr. Kirkpatrick, in his exploratory survey of the Manitou route for the Canadian Pacific Ry., to be 107 feet. This in a distance of about 12 miles, gives a mean slope along the water course of nine feet in the mile. On the Sand Island River route, the drop of the water from the N.E. corner of the region mapped on the Rainy Lake sheet to the level of Rainy Lake is estimated to be about 120 feet. The distance being about 24 miles, this gives a mean slope of about five feet in the mile.

Rainy Lake, a receiving basin for extensive circle of country.

The slope to Rainy Lake.

The absence of great contrasts of elevation, associated with the remarkable hummocky or mammilated surface, already mentioned, which characterises this plateau, are features which it has in common with the Archæan plateau in general of which it forms a part. Taking the surface of Rainy Lake as a local datum level, there are few portions of the country that rise to an elevation of 100 feet in the immediate vicinity of the lake. The only exception to this is the ridge of schists on the north side of the lake between the Bear's Passage and Open water Narrows. This ridge attains a height of about 250 or possibly 300 feet above the lake. From its crest a vast sweep of country may be seen in all directions, and when travelling on the lake, it forms a prominent land mark. Further to the northward, the surface of the plateau slope has a general maximum elevation of 200 feet above the lake. Two or three notable exceptions may be mentioned, although they do not seriously affect the general statement. One of these is the group of conical or dome-like hills of granite or granitoid gneiss which rise to an elevation of about 300 feet above Lake Harris at its west end. This would be about 450 feet above

Hummocky surface.

Elevations.

Rainy Lake. These hills stand very prominently above the general level of the country and can be seen from Manitou Lake many miles to the north-east. Kishkutena ridge, which forms the divide between the waters running into Sabaskong Bay, and those running into Rainy Lake, is probably 500 feet above the assumed datum level. The land lying to the south of Crow Lake rises in an east-and-west trending ridge, which is in somewhat prominent contrast to the surrounding country. With a few exceptions like these, the surface is remarkably uniform in general elevation, within the limits mentioned; and it is only the endless diversity of detail, the ever-changing harmony of water, rock, and forest, in all the various atmospheric keys, that conceals the monotonous flatness of the region. Such being the general maximum elevation of the region, it becomes a matter of interest to ascertain the minimum elevation or maximum depression. All the depressions or basins of the plateau which have a continuous rim, nowhere as low as the bottom of the basin, are filled with water, and form lakes, each of which, under ordinary conditions, is in a constant state of overflow into the next lower basin. In very dry seasons, the overflow and evaporation exceed the amount of precipitation gathered from the country tributary to any particular basin, and the water of the lake is temporarily stagnant. This is particularly the case with lakes at the head of a chain. These head-water lakes are sometimes, as in the case of Kishkutena Lake, the largest of the chain to which they belong, and may, under the conditions mentioned, be seen with the level of their surface several inches lower than the rim of the containing basin at the outlet. To form an approximate estimate of the depth of the depressions in which these lakes lie, a series of soundings has been made, which, although by no means complete, affords sufficient data upon which to base an estimate of the general depth of the basins. A list of these soundings is given below. The figures indicate that the depth of these depressions, below the contour line afforded by the lake shores, approximates as nearly as can be judged to the general elevation of the country above that line. Thus, if land and water surfaces were in equal proportions, the level of the water would be the mean elevation of the rocky surface of the region; or rather the mean slope of the chains of lakes would be the mean slope and elevation of the plateau. But as the land surface very much exceeds the water, the mean elevation of the plateau must be somewhat higher than the shore line contour.

Highest point of Rainy Lake region.

Depressions.

Soundings.

Relationship of depressions to elevations.

Deepest lake.

The greatest depth of water anywhere observed was that of Pickerel Lake on the Manitou route, where the sounding showed a depth of 165 feet. The next deepest sounding was on Manitou Lake, where I found 158 feet of water as the maximum of a series of soundings in the lower

part of the lake. It is of interest to note that these maximum depths of water are in a line of depression which appears to be connected in origin with the fault observable at Cedar Narrows on Pickerel Lake. The lowest depression of the region is that of the south arm of Rainy Lake south of Little Rocky Narrows or opposite the mouth of Seine Bay, where the water is 110 feet deep. This is the maximum depth found anywhere on Rainy Lake, and taken in connection with the low level of the surface of the lake, compared with that of the other lakes draining into it, it gives for the bottom of the lake at this place the minimum elevation of the region. The maximum elevation of the region was found to be the summit of Kishkutena Ridge, which was placed at about 500 feet above the surface of Rainy Lake. The difference between the maximum and minimum elevation, or the range of altitude of the various parts of the plateau is thus 600 feet. Reference has not been made to the sea level, because the altitude of our local datum level is not known with sufficient accuracy to be of service.

Greatest depth in line of fault.

Maximum depth of Rainy Lake.

The following is a list of the various determinations that have been made for the elevation of Rainy Lake above the sea:—

Elevation of Rainy Lake above sea.

	Feet.
1. Colonel Lefroy, barometrical, as quoted by H. Y. Hind......	1,160
2. S. J. Dawson, by way of Pigeon River route............. ...	1,045
3. " " Seine River "	1,029
4. " " Dawson route......................	1,035
5. Major Long (Lake Superior 595 feet.).....................	1,100
6. W. B. Kirkpatrick, by way of Manitou route................	1,094

I am inclined to regard the first of these determinations as being nearest the truth. Of S. J. Dawson's determination Nos. 2 and 3, are taken from his official report. They are based upon actual measurements of falls and estimations of rapids and currents on the two cano routes mentioned, from Lake Superior to Rainy Lake. No. 4 is given by Hind in his report on the Red River exploring expedition, and credited to Mr. Dawson, with the statement that the level of Lake Superior is taken at 600 feet above the ocean. All three determinations are under-estimated. Since they were made the levels along the line of the C. P. R. afford an important check upon them. These levels place the surface of the Lake of the Woods at its lower end at 1,062 feet above the sea. The Rainy River affords abundant testimony of a very marked difference of elevation between Lake of the Woods and Rainy Lake. If we assign to the Coutchiching Rapids a descent of 5 feet; to the falls of Fort Frances, 22 feet; to the Manitou Rapids, 5 feet; to the Longue Sault Rapid, 10 feet; and to the general current of the river, which is remarkably strong and swift, a descent of 1 foot in the mile or 75 feet, all of which estimates are moderate, we would

Discussion of data for level of Rainy Lake.

have, as the difference of level between Lake of the Woods and Rainy Lake, 117 feet, to which may be added 3 feet for the difference in the level of the upper and the lower end of the Lake of the Woods, making a total difference of 120 feet. This added to the level of the Lake of the Woods, as determined by the C. P. R. engineers, would give us, as the elevation of Rainy Lake, 1,182 feet. Assuming its correctness, the highest land within the region mapped, the crest of Kishkutena ridge, is about 1,700 feet above the sea level; and the lowest hollow, Rainy Lake south of Little Rocky Narrows, about 1,072 feet above the same level.

List of Soundings in Rainy Lake and in some of the Lakes Tributary to It.

	Feet.
Manitou Sound, 1½ miles S. E. of Devil's Cascade	39
" " opposite mouth of Little Canoe R	54
Ash Bay, North arm	80
" West of Boreas Island	32
Channel between Boreas Island and Gube Point	31
Off S. E. shore of Argyle Island	29
Off S. E. shore of Boom Island	25
Alexandria Bay, north channel	31
Off south side, Cherry Island	30
One mile N. of Hanging stone Point	23
Half mile N. of N. W. end of Woodchuck Island	27
West of N. W. end of Woodchuck Island	24
North West Bay, Camp Narrows	30
" " opposite Brown Inlet	35
Off S. E. end of Woodchuck Island	27
Off West side of Rebecca Island	36
Off S. W. end of " "	33
Half mile N. N. E. of Standing-stone Point	32
Channel south of Chamberlin Point	60
North-east Bay, 4½ miles west of Frog Portage	60
" 3½ " "	55
Channel S. E. of Rebecca Island	27
" East end, Cheery "	43
" West " "	42
Off Tug Point	50
1½ miles W. S. W. of Blaze Point	57
2½ " " "	63
2 " S.W. "	72
1 mile N. W. of Reef Point	60
One mile W. of Reef Point	45
Between Homestretch and Risky Islands	37
¾ mile S. of Homestretch Island	38
Opposite entrance to Stanjikoming Bay	49
" Hay Marsh Bay	40

	FEET.
Sand Bay	23
One mile S. S. E. of Little Rocky Narrows	70
Two miles S. " "	110
" S.E. " "	105
Channel between Dry Weed Island and south shore	33
Opposite mouth of Seine Bay	105
2 miles E. of Hallelujah Point	80
2 " E. of Brulé Narrows	22
4 " E. " "	60
5½ " E. " "	74
S. of Vague Point	82
S of Breezy Island	59
Off N. side of Oak Point Island	59
One mile S. W. of Pine Narrows, Redgut Bay	45
Opp. mouth of Crow Rock Inlet, "	45
" " Porter Inlet, "	22
Parry Strait, "	6
Mainville Lake, north end	27
" " middle	18
Obikoba Lake, south end	16
" " north "	14
Captain Cuttle Lake, south part	31
Sam Weller Lake	16
Twist Lake	36
Dog Fly Lake, middle	68
" "	92
South end of Grant Lake	90
Middle " "	42
North end " "	126
Sairey Gamp Lake	27
Lake Harris	99
Missus Lake	75
Lake, west of Missus Lake	66
Kaiarskons Lake	118
Furlonge Lake	30
Crack Shot Lake	27
Sakwite Lake	63
South end of Kahopskikomak Lake	48
Middle " "	34
Kahwawiagamak Lake	45
Memekwesi Lake	67
Down-grade Lake	43
Smooth-rock Lake Narrows	76
" " S. end	30
Windigons Lake	87

		FEET.
Pickerel Lake		165
Manitou Lake, opposite Snare Bay		60
" "	N. E. of mouth of Hidden River	96
" "	N. E. " Peep Bay	158
" "	N. E. of Paddle Portage	129
" "	1¼ miles N. E. of Paddle Portage	117
" "	2 " " "	87
" "	2¾ " " "	110
Clear-water Lake, S. end near Burnt Narrows		50
" "	middle	56
" "	north end	28
First Quill Lake		47
Narrow Lake, S. W. end		75
" "	middle	122
" "	N. E. end	40
Height of Land Lake, S. end		63
" "	N. end	44
Kishkutena Lake, near narrows		52
Kahtimiagamak Lake		50
Pipestone Lake, S. end		105
Three Island Lake		50
Bat Lake		40
Cold Lake		42
Strong Lake		47
Vane Lake, N. end		60
"	S. end	50

Average. The average of the soundings in Rainy Lake, 51 in number, is 47·4 feet, which is probably not far from the average depth of the lake, as the depth of the water does not depend so much, in those rocky basins, upon the distance from shore, as it does in lakes lying in soft or shelving strata. The average of the soundings, 54 in number, in the lakes higher up on the plateau, is 63·6 feet, which represents not an average depth of these lakes, but rather their average maximum depth.

Dependence of contour upon geological conditions. The intimate dependence of topographical contour upon geological conditions which was observed upon the Lake of the Woods is equally well exemplified upon Rainy Lake, and on the other lakes of the region. The shapes and disposition of the lakes and the trend of the ridges and depressions are always a function of the character and disposition of the rocks; and show that the agencies of erosion have acted along lines and with varying intensities, which were determined by the nature of the rock itself long before those agencies had access to it. This fact comes out much more strongly, of course, in those portions of the region which are occupied by the schists of the Keewatin and Coutchiching series, or in the more gneissic portions of the Laurentian, than

in the more granitoid portions of the latter. Still the principle is well illustrated even here by the irregular shape of the lakes, and the more irregularly hummocky character of the surface. Since in the more granitoid country there are few or no structural lines to give direction to decay and erosion, and these, therefore, act with equal ease in any direction.

Leaving the lakes which lie in the more granitoid of the Laurentian gneisses, and passing to the consideration of those lying in more evenly laminated or schistose rocks, it will only be necessary to draw attention to a few of the many instances which illustrate the principle in order to emphasize its force. Beginning with Rainy Lake itself, we find that it consists of two main arms, an east arm and a north arm, diverging at right angles from its outlet at the south-west corner. The east arm comprises three distinct basins or troughs, viz.:— **Illustrations of this dependence.**

1. From the outlet at Coutchiching to the bottom of Swell Bay, a trough 20 miles long and very narrow, compared with its length. That portion of it which is east of Open-water Narrows has an average width of one mile and its axis or mean course is 70°. The portion west of Open-water Narrows has a bearing from the narrows to Coutchiching of 75°, and its average width is something over two miles. A glance at the geologically colored map will show that these bearings are very closely those of the mean strike of the rocks at these two portions of the trough. **First trough.**

2. From Grassy Narrows to the bottom of Seine Bay, a trough 21 miles long. The axis measured along the longest line of open water has a bearing of 76°. The trough has a width, at its middle part, of about four miles and tapers towards Grassy Narrows almost to a point while to the eastward it passes into Seine Bay, a stretch of water seven miles long with parallel shores one mile apart. **Second trough.**

These two troughs are separated by a long, narrow, tapering ridge of rocks, which, westward of Little Rocky Narrows, is continued in a belt of narrow, elongated islands, separated by very short transverse channels. This dividing ridge has a trend coincident with that of the water-filled troughs on either side of it, and strictly coincident with the mean strike of the schists of which it is composed. **Separating ridge between troughs.**

The parallelism of the shore lines which form the rim of this second trough or basin to the strike of the schists is everywhere observable even in great detail. The divergence of the shores which makes the middle of the basin wider than the ends, is due to a similar divergence of the strike, the rocks on the north side having a strike of about 75°, while on the south shore, from Black Bay to Brulé Narrows, the strike is east and west. Dry-weed Island and the islands near the mouth of Seine Bay and Brulé Narrows are all long and narrow, and have their longest axes parallel to the strike of the rocks.

Seine River, a continuation of second trough.

The Seine River and its lake expansions forms a trough whose mean axis is strictly parallel to that of the trough just described. The trough extends from Bleak Bay, with a bearing of 75°, 22 miles to the limit of the region mapped. The minor deviations from the mean line or axis always follow curves in the strike of the rocks.

Third trough.

3. The last of these troughs or basins which, together, make up the east arm of Rainy Lake, is that which lies between Brulé Narrows and Kettle Falls. It is separated from the second trough by points of land which approach each other at Brulé Narrows. Its greatest length is 19 miles along the line extending on a bearing of 97° from the bottom of Saginaw Bay to the bottom of Stokes Bay. This line of greatest length is not, however, the true axis of maximum erosion, and to bring out the parallelism of the maximum erosion and of the trend of the shore lines to the strike of the rocks, it will be necessary to regard this trough as made up of two sub-troughs.

Composed of two sub-troughs

The axis or longest diameter of the first of these extends 85° from the bottom of Saginaw Bay, 13 miles to the bottom of Cormorant Bay. This line coincides very closely with the mean strike of the rocks. The second sub-trough extends from Big Island to the bottom of Stokes Bay, a distance of 12 miles. Its axis and the mean strike of the rocks, from which there is but little deviation, are both east and west.

North arm of Rainy Lake, its cross-shaped basin.

The north arm of Rainy Lake has a trough which takes the form of a cross. The portion of the trough corresponding to the larger bar of the cross, often 5 to 6 miles wide, has for its mean course a due north-and-south line extending from the south shore of the lake past Squall Point to the vicinity of the Devil's Cascade, a distance of 24 miles. The portion corresponding to the transverse or narrower bar is somewhat curvilinear, concave to the north, and extends from the west end of the North-west Bay to the east end of Redgut Bay, by way of Frog Portage, a distance of 38 miles. The whole of this cross-like basin lies in Laurentian gneiss, which is, for the most part, distinctly foliated or laminated; and both the N. and S. and the E. and W. trending troughs, which together form the basin, conform strictly to the strike of the planes of foliation of the gneiss.

Coincidence of shore line with strike.

The irregularities and apparent exceptions to the rule are due, for the most part, to masses of granite which cut the gneiss in places. From the Devil's Cascade at the extreme north end of the lake down to the entrance to the North-west Bay on the west side, and to the entrance of the North-east Bay on the east side, this coincidence of shore line with the strike of the rocks is perhaps best exemplified. From the Devil' s Cascade southward, the trend of the rocks diverges, curving around on the one side so as to strike up the North-west Bay, and thence through Foot-print Lake, Jack-fish Lake and Loon Lake, the strike of the rocks making a complete circle, and

closing again on itself at the Devil's Cascade. This circular disposition of the foliation is closely followed by the shores of Manitou Sound, Ash Bay, Alexandria Bay, the Islands of Manitou Sound, the shores of the North-west Bay and the lakes above named. On the other side, the curve of the strike is first to the south-east into the North-east Bay, and then east through Macdonald's Inlet, Black Sturgeon Lake, Crow Rock Inlet and Redgut Bay. Where the rocks cross the lake with an east and west trend, the long axes of the islands all lie in the line of strike. From Standing-stone Point southward, the rocks curve around from east and west to north and south, and the shore and off-lying islands have the same trend. On the east side of the lake, between the North-east Bay and Gash Point, the shores of the bays and the more prominent points are coincident with the strike.

Circular disposition of strike of gneisses.

Among the more striking instances of the minor lake basins showing parallelism of contour to the strike of the schists in which they lie, may be mentioned the following: Narrow Lake, north of the N. E. end of Sabaskong Bay; the south part of Crow Lake; the whole of the waters of the canoe route from the south-east end of Crow Lake to the North west Bay of Rainy Lake by way of Boulder, Schist, Pipestone, Link, First Quill, Clearwater, Minomin, and Despair lakes. This chain of lakes forms a Z-shaped trough lying almost entirely in the Keewatin schists. The two sharp bends in the water course, at the N. E. end of Pipestone Lake and at the south end of Clearwater Lake, correspond closely to two sharp bends in the strike of the rocks. The lakes are all narrow in proportion to their length. Manitou Lake, Grant Lake, Missus Lake, Strawberry Lake, and other smaller lakes in this portion of the Keewatin belt, are remarkable for the fidelity with which they adhere to the strike of the rocks and for their long, narrow shapes. The exceptional case of Pickerel Lake, with its irregular shape and long axis, transverse to the strike, finds its explanation, doubtless in the two granite bosses which interrupt the strata, and in the fault which dislocates them at Cedar Narrows. Dog-fly and Vista Lakes conform in their general contour to the strike of the rocks, but are somewhat irregular in shape as are most basins eroded out of agglomerates. Kahopskikamak and Sakwité lakes on the Otukamamoan route, Little Turtle Lake, Tésup, Big Sawbill, Otter and Mainville lakes, are notable instances of basins in Laurentian biotite gneiss which are long and narrow, and have their shores determined by the position of the planes of foliation. These various instances here cited are only the more prominent ones which come out in the mapping, but on the scale on which the map is published there is a host of details lost, in which the topographical contour is in the closest dependence upon the character and structure of the

Instances of minor lake basins coinciding in shape with strike of rocks.

Exceptional case due to fault and irruptive granite.

rocks. This dependence impresses one very forcibly in the field, but cannot here be more than alluded to, except where, as above sketched, it affects the main topographical features of the region.

The Alluvial Plain or River Country.

Extent of alluvial plain.

Its slope.

The wooded plain which extends from the south-west corner of Rainy Lake to the Lake of the Woods is on a slight but distinctly lower level than that of the "rocky lake country." Its slope is apparently the continuation of that of the rocky plateau just described. The highest part of the plain, so far as I was able to observe, is where the scarped face of the bedded clays which underlie it overlook Rainy Lake near Coutchiching, with an elevation of 10 or 12 feet above the surface of the lake. Down the Rainy River to the Lake of the Woods, the plain has practically the same slope as the river, and on the Lake of the Woods between Hungry Hall and 49th parallel, the edge of the plain has an elevation of from 10 to 20 feet above the surface of the lake, and according to Mr. Bolger* extends back with "extreme levelness" over townships one and two, south ranges XXIII and XXIV. Between these two points of maximum and minimum elevation of the surface of the plain, the slope is apparently gradual and uniform, the average incline in a W. N. W. direction, being probably two feet in the mile. Occasionally, as to the north-west of the Indian Reserve at the Longue Sault on Rainy River, the country is rolling or undulating, an appearance which is probably due to the ridged character of the concealed rocky surface, at a place where the covering of post-glacial deposits is thinner than usual. Occasionally too, a knob of rock projects through these deposits, which has been either exposed by local denudation of the clays, as at different rapids of the river, or which appears to have been a small islet in the vast lake in which these deposits were laid down. Such island-like knobs of rock have usually a more or less distinct formation of shore gravel about their base, as, for instance, the knob which projects above the plain on the northern limit of the Longue Sault Indian Reserve, or the portion of trap dyke observed at the back of Mr. Lutterel's farm. The uniform flatness of the plain affords no depressions which serve as lake basins, and none are known beyond a few mere ponds. Drainage is effected by the numerous creeks and rivers which flow into the Rainy River. These all cut channels down through the clayey strata, and afford excellent sections of a thickness varying from 10 to 30 feet. The most important tributary, on the Canadian side, is Pine River, a narrow stream, sluggish at low water, whose principal branches flow in the bottom

Rock exposures

Drainage.

* Report, Commissioner of Crown Lands, Ontario, 1886, p. 48.

of the low valleys in the undulating surface above referred to. Several much larger streams feed Rainy River from the American side. The undrained water rests on the surface of the plain in the form of muskegs and swamps. Mr. Bolger estimates that "perhaps 30% of the area is swamp, most of which can be drained and made tillable land." Rainy River has, at the mean height of the water, a depth which, from a number of soundings in mid-stream, appears to vary from 15 to 21 feet. At the Longue Sault and Manitou Rapids it is, of course, shallower, but not so shallow as to obstruct navigation except at very low water, when the boulders in the channel of the Longue Sault obstruct the passage of the small screw-steamers which ply between Rat Portage and Fort Frances. The serious obstacle to navigation is the falls of Fort Frances. The completion of the locks at Fort Frances, all the heavy and expensive work of which is done, would extend navigation very much, and stimulate the development of this portion of the country. The general features of the river have been well described by Bigsby*, Hind†, Long‡, and S. J. Dawson§.

Extent of swamp.

Depth of Rainy River.

Lock at Fort Frances.

ARCHÆAN GEOLOGY.

GENERAL STATEMENT.

The Archæan rocks of the Rainy Lake region, like those of the Lake of the Woods, are clearly separable primarily into two main divisions, viz.: An upper, chiefly schistose, bedded, and metamorphic: and a lower, of the granitic or syenitic type of mineralogical composition, but mostly gneissic in structure. In the upper division there can be recognized at least two distinct groups. One of these is identical with the Keewatin series of the Lake of the Woods,¶ and has been traced stratigraphically in direct continuity with it. The other is prominently developed in the southern part of the region, and occurs between the base of the Keewatin series and the Laurentian. Being unable to correlate this second series with any with which I am acquainted, I have named it, in a preliminary notice ** of the geology of the region, the Coutchiching series. †† In the lower division distinctions of stratigraphical sequence and relationships, if any such ever existed, have been obliterated. For this assemblage of rocks or lower division of

Upper and Lower Archæan

Distinctive characters.

Keewatin series.

Coutchiching series.

* Geol. Journal, Vol. VII, 1851, and Vol. X, 1854.
† Report of the Red River Exploring Expedition, 1858.
‡ Sources of Peter's River, Keating, 1825.
§ Appendix to XVII Vol. of Journals of Legislative Assembly, 1859.
¶ Annual Report, Geological and Natural History Survey, 1885, Part CC.
** Am. Jour. Sci., Vol. XXXIII, June 1887.
†† This series presents interesting lithological resemblances to the Montalban series, but has not the geological position which has been assigned to the latter,

the Archæan, the term Laurentian is retained. The Laurentian rocks in this particular field can be classified only on a petrographical basis. The different kinds of rocks which are comprised within the assemblage so named are susceptible of a geographical separation into zones or areas, but, as above stated, are not geologically separable into strata or bedded formations, though often stratiform.

Schematic representation.

The leading divisions of the Archæan for this region may, from what has been stated, be arranged in the following scheme, according to the order of which the geological features of the region will be considered in detail:—

$$\text{Archæan.}\left\{\begin{array}{l}\text{Upper division.}\quad a.\ \text{Keewatin.—(Huronian ?)}\\ \qquad\qquad\qquad\quad\; b.\ \text{Coutchiching.}\\ \text{Lower division.—Laurentian.}\end{array}\right.$$

A more comprehensive statement of the results arrived at, together with a discussion of their theoretical bearing, will be given in the summary, after the facts, upon which these and other generalizations are based, have been set forth.

Keewatin Series.

Limits of the Area of the Keewatin Rocks—Conditions of Contact with Lower Rocks.

Keewatin series on Lake of the Woods.

At the S. E. corner of the Lake of the Woods map, 1885, the Keewatin rocks are represented as in contact with the Laurentian gneiss on the shore of Sabaskong Bay, at a point a little to the east of the portage road which leads from that bay to Arrow Lake, through the Indian Reserve 35 C. From this point eastward, the line of contact curves to the north, around the extreme N. E. inlet of Sabaskong Bay, the trend of the shore being approximately parallel to the curvature of the line of contact. The shores of this inlet are all very coarse granitoid gneiss or granite. The contact line lies in the ridge of land which divides the waters of Sabaskong on the south from those of Arrow Lake and Crow Lake, on the north and north-east, and runs much closer to the former than to the lakes named. The last exposure on the Lake of the Woods at which the Keewatin rocks and the Laurentian gneisses are seen in contact is at the northern extremity of the S. E. arm of Sabaskong Bay, close to the south end of Crow portage. In coming over Crow portage, from Crow Lake to Sabaskong, the rocks passed over are black-green, hornblende schists. They are first seen about one-third of the way from Crow Lake, with a strike of 130° and dip at high angles to the north-east. Four chains farther south they have a strike of 140° with

Rocks on Crow Portage.

the same dip. Beyond this to the end of the portage they are seen at intervals with a uniform S.E. strike; dip N. E. At the end of the portage, on the shores of the bay, on the west side, the schists come in contact with a medium-grained, flesh-tinted, or reddish to grey, biotite gneiss, which exhibits, for the most part, a very distinct and even foliation of the constituent minerals, quartz, felspar and biotite. This foliation is approximately parallel to the schistosity of the hornblende schists; the contact is, however, a brecciated one, the gneiss being apparently injected into the schists, which seem to have been more or less shattered in a brittle condition, so as to admit of the passage of the gneiss in its former soft and plastic state within the fissures of the schist, which are sometimes parallel and sometimes transverse to its cleavage planes. The strike of the rocks at the contact is 130°, dip N. E. $<$ 60° to 70°.

Contact of Keewatin and Laurentian.

The next place where this line of contact was crossed by our surveys is on Kah-timi-agamak Creek. The interval between the last described point of contact, at the south end of Crow portage and this creek is about nine miles. But although the line of contact has not been actually traced out for this interval we know that it must occupy approximately the position given to it on the map, from our knowledge of the distribution of the Laurentian rocks to the south, on the shores of Sabaskong Bay, Kah-kabik-kitchiwan Lake, Crooked-pine Lake, Big-pine Lake and Wigwam Lake, and of the Keewatin rocks to the north on the shores of Crow Lake and Kah-timi-agamak. The contact of the gneiss and hornblende schist occurs on the creek about half way between Wigwam and Kah-timi-agamak lakes. The actual contact is not well exposed, but the rocks on either side can easily be traced along the creek and shew that a very granitoid, reddish, biotite gneiss comes in contact with a dark, green, hornblende schist, which gives way, a little further up the creek, to green agglomerate schists.

Contact on Kah-timi-agamak Creek.

To the south-eastward of Kah-timi-agamak Creek the line of contact appears to continue in the same general direction for about four miles, when it begins to curve around to the south, so that on the north side of Night-hawk Lake, where the contact is next seen, the strike is about north and south. Following it across Night-hawk Lake and thence for nearly a mile and a-half to Kishkutena Lake, we find that the line of contact curves rapidly to the S. W., and from the last named lake onward it has a course which makes an angle of 70° degrees with that which it formerly held between the south end of Crow Portage and a point to the north of Night-hawk Lake. The west side of Night-hawk Lake is occupied by a rather coarse, reddish, granitoid, biotite gneiss or granite, composed of quartz, in large grains, and orthoclase in about equal proportions with a subordinate proportion of biotite. This rock

Contact at Night-hawk Lake.

is not only observed to occupy this shore of the lake, but is seen to make up the bare burnt hills which extend for some miles to the westward. The east side of the lake is occupied by the Keewatin rocks which form a comparatively high ridge with an abrupt face to the north-west. This ridge runs from this point south-westward for several miles and extends to the south of the 49th parallel, forming the divide between the waters flowing into the Lake of the Woods and those flowing into Rainy Lake. The rocks of the Keewatin series which compose this ridge, particularly on its north-west side, differ from the ordinary hornblende schists which are usually found in contact with the Laurentian gneisses, in being very much more compact and often quite devoid of schistose structure. The rock appears, to the naked eye, to be, like the schists, composed mostly of hornblende, but has, in addition, numerous large porphyritic crystals of white felspar, studded all through it, so that on the large scale, on the face of a cliff for instance, the rock presents a distinctly and curiously mottled aspect although in hand specimens it is often difficult to get more than one or two porphyritic crystals. This rock is very probably an altered porphyrite, and grades into more schistose varieties with the disappearance of the felspar. The same rock has been noted at the contact of the Keewatin series with the Laurentian on the north side of White fish Bay, Lake of the Woods.* The contact of this altered porphyrite with the granitoid gneiss runs along the base of the cliff which forms the north-west side of the ridge above mentioned, and as the rocks are well bared, may be traced easily from the south end of Night-hawk Lake to the N. E. end of Kishkutena Lake.

Kishkutena Ridge.

The rocks composing the ridge.

The granitoid gneiss is here mixed, only to a very limited extent, with the Keewatin rocks, a fact doubtless due to their unusual compactness and toughness at this locality. At the north-east end of Kishkutena Lake, one-quarter of a mile from Kishkutena portage, the actual contact is not exposed, and between the nearest exposures of the granitoid gneiss and the porphyrite, there is a small exposure of a greenish, grey quartz porphyry made up of an aphanitic ground-mass in which are imbedded crystals of felspar. Whether this porphyry is only a local porphyritic facies of the granitoid gneiss, or whether it is a later intrusion, or even an older formation incorporated with the porphyrite, there is no evidence to determine. For two miles farther to the S. W., the line of contact runs under the waters of the lake, the rocks on one side of the narrow arm being the altered porphyrite of the Kishkutena ridge, and those on the other the Laurentian granitoid gneiss. This gneiss is here often quite devoid of foliation and is then more properly a granite, though both the foliated and non-foliated

Quartz-porphry at contact.

Continuation of the line of contact.

* v. Annual Report, 1885, pp. 38-39 cc.

varieties are part of the same geological mass. After leaving the south side of Kishkutena Lake, the line of contact of the Laurentian and Keewatin rocks continues for five miles in the same S. W. course, and is next intercepted on Little Kishkutena portage one mile south of the 49th parallel. The conditions of contact are here quite analagous to those noted between Night-hawk Lake and Kishkutena Lake. The same ridge of Keewatin rocks composed of hornblende schists and altered traps, schistose or massive, has been traced for six miles farther to the S. W. through the lakes of the Little Kishkutena route to the west end of Off Lake. Here the schists have a strike of 50° and dip to the S. E. at < 70°. Throughout this distance the actual contact of the Keewatin rocks on the N. W. side of the ridge with the Laurentian gneisses has not been observed, but there is little doubt but that it follows the same line as to the N. E. of Little Kishkutena, the strike of the rocks and the trend of the country remaining constant. To the west and southwest of Off Lake the country becomes low and flat, with little or no exposure of rock, so that the course of the contact of the Keewatin rocks with the gneisses cannot be accurately determined. The rocky surface of the country passes under the post-glacial deposits of Rainy River valley, and for 16 miles, in the direction of the strike where last observed at Off Lake, we have no evidence as to the distribution of the rocks. The black, green, hornblende schists of the Keewatin are next seen in considerable volume on Rainy River. They crop out along the river from a point about one-quarter of a mile above the Longue Sault Rapids to near the foot of the same, where they appear to be in contact to the south with a rather coarse-grained, reddish, granitoid gneiss, which is exposed on two small islands at the foot of the rapids opposite the chief's house. The strike of the schists along the rapids is with the direction of the river or E. and W., and the dip is northward at angles which are, at places, as low as 45°. In passing northward from the river through the woods on the Indian Reserve, the schists are occasionally observed projecting through the soil, and on the northern limits of the reserve between four and five miles from the river, across the strike of the schists, they are exposed over several acres on the crest of some *roches moutonnées*, and have a strike of 80° with a southerly dip at an angle of 65°.

Contact on Little Kishkutena Portage.

Keewatin rocks on Rainy River.

On a small creek that empties into Rainy River about three miles and a half below the Longue Sault, I am informed by Mr. Cameron, who resides on the river near the place, that there is a small exposure of similar schists, and that on a logging road, which runs four miles back from Rainy River, there are three other exposures of similar rocks.

The next place where I have seen these rocks myself is where they are crossed by Pine River some seven miles west of the exposure

Keewatin rocks on Pine River.

described on the north side of the Longue Sault Reserve. At the first rapids on Pine River, about four miles up from Rainy River, a fine-grained, green, compact, hornblendic rock is exposed with a schistose structure only slightly developed in it. For a mile and a-half farther up Pine River, to the second rapids, there are several exposures of the same rock. From this point, up stream, as far as it is possible to travel, there are no further rock exposures.

Thus combining all the evidence at our disposal regarding the distribution of these Keewatin rocks on the north side of Rainy River, below the Longue Sault, we find that they have an extensive development; and although they are for the most part concealed by post-glacial formations, it appears to be tolerably certain that they have a breadth across their strike of at least eight miles. The main branch of Pine River flows in a W.S.W. direction in a shallow valley which has for its southern boundary a fairly well marked ridge. This ridge, though covered with soil and well rounded, is, I take it, the continuation of the Kishkutena ridge, which makes itself apparent in spite of its mantle of post-glacial formations. It was found at Night-hawk Lake, Kishkutena Lake, and at Little Kishkutena portage, that the line of contact of the Laurentian gneiss and the Keewatin rocks lies in the valley or depression which skirts the Kishkutena ridge on its north-west side, and it seems probable that the conditions which were observed there continue to prevail to the south-west, so that the valley of the main branch of Pine River corresponds with that in which lies Nighthawk, Kishkutena and Little Kishkutena Lakes, and the line of contact of the Laurentian and Keewatin coincides approximately with the course of Pine River from Sec. 36, tp. 3 S., R. XXVI, to Sec. 18, tp. 3 S., R. XXV.

Kishkutena ridge indicates probable line of contact.

Other exposures on Rainy River.

West of Pine River, the next exposure of the Keewatin rocks on Rainy River is at the mouth of Rapid River on the American side. The rocks here are not, however, hornblende schists or altered traps, but fine-grained, grey, compact, clastic rocks, such as occur in the upper portion of the Keewatin series. They are distinctly bedded and in places slightly schistose and micaceous, and dip N. W., $< 60°$, the strike corresponding with the course of Rainy River immediately above Rapid River. The only other formations observed on Rainy River, from Rapid River down to the Lake of the Woods, are of post-glacial origin.

Keewatin and Laurentian rocks on S.E. coast of Lake of the Woods.

At the mouth of Rainy River and on the south-east shore of the Lake of the Woods, between Hungry Hall and Little Grassy River, we again meet with the Keewatin rocks, although only in isolated exposures, and then much mixed with the Laurentian gneisses. This portion of the lake is unique in running transverse to the strike of

the rocks, a circumstance due, probably, to the fact that the shore is made up of rocky points, with sands and other post-glacial matter filling up the intervening hollows. Were the loose deposits removed, we would have, as is the general rule in this region, long, narrow bays or channels occupying their place, and lying between the ridges which terminate on the lake shore in the rocky points above mentioned. On these points and at the mouth of the river, the rocks are found to have a very regular strike of W.N.W. to N.W. and it would seem that to the westward of Pine River they gradually curve around from an E. and W. strike to one having a bearing of W. N. W. and then N.W. This inference is borne out and supported by the fact, that the bed of Rainy River curves around precisely in the way indicated, and the close dependence of the physical features of the country upon the geological structure gives such a fact great significance, where direct evidence as to the structure is wanting. Wherever rock exposures have been noted on Rainy River, the strike has been invariably coincident with the course of the river at the particular place where the rocks crop out, and there is good reason for believing that where they are not so exposed, the course of the river indicates the strike of the underlying rocks.*

Evidence of strike drawn from topography.

Observations on S.E. coast of Lake of the Woods.

At the mouth of Rainy River, on a small island near Michel Morriseau's house, and on the lighthouse plot, there are exposed rather massive, black, green, crystalline, hornblende schists, which are composed sometimes of hornblende only, and sometimes of hornblende and felspar. These schists strike N.W. Following the shore northward there is no other rock exposure for six miles, when a low point juts out of the sand which is mostly made up of black, green, hornblende schist, striking 100° to 110°, but with considerable biotite gneiss. The latter is often associated with the schist so as to produce a very evenly banded appearance, but here and there the gneiss cuts the schist transversely, as if the gneiss had been injected along the planes of cleavage of the schist and thus produced the banded appearance presented. Half a mile farther along the shore, a similar point is composed entirely of black-green, hornblende schist, strike 110°, dip vertical. On Burton's Island, the rock is a grey, biotite gneiss, strike 100°, and similar rock occupies the small bare islet just to the north-east of it. On the neck of land which runs out from the main shore, about half a-mile to the N.E. of Burton's Island, the rock is a mixture of hornblende schist and biotite gneiss, often presenting a remarkably even ribanded aspect, but still affording sufficient evidence of the intrusive character

Burton's Island

* Dr. Bell observes in his report for 1873-74, on much less evidence than is at my disposal, that "there is reason to believe that under these superficial deposits a broad band of Huronian (Keewatin) rocks crosses the lower section of the river."

of the gneiss. The strike is here 120°, dip vertical or north at very high angles. Half a mile farther north, the same mixture of hornblende schist and gneiss is observable, strike 115°. On a small shoal about half-way between Burton's Island and the south end of Bigsby Island, which is strewn with huge angular boulders of gneiss, the rock is hornblende schist, strike 155°. On the extremity of Windy Point and on Buzzard Island, as well as the extremity of the point of land which forms Indian Reserve 35 E. the same mixture of hornblende schist and gneiss occurs, the prevailing strike being 145° to 150°, and the dip either vertical or to the north, at angles not less than 75°. On the shore south of the mouth of the Little Grassy River the rock is biotite gneiss. North of the Indian Reserve 35 E, the only rocks exposed are gneisses.

Windy Point.

Little Grassy River.

Thus the trough of Keewatin rocks, one of the confines of which we have traced, with varying degrees of certainty, from the N.E. corner of Sabaskong Bay, and indeed from the extremity of Rabbit Point,* in a sort of a horse-shoe curve, around by the south of Kah-timi-agamak Lake, along the north-west side of the Kishkutena ridge and the south side of the Pine River valley, out to the Lake of the Woods again, appears, as it emerges upon the lake, to be very shallow and diffuse. All that remains apparently of the voluminous series of schists are the bottoms of in-pinched folds, much mixed with the gneiss, in which, in its once soft and plastic state, they appear to have been immersed. To define the limits of the belt in its scattered, diffuse and brecciated condition is not possible, and it only remains to be noted that it is extremely probable that the belt, which has been traced, as above indicated, for five-sixths of a complete circuit, once closed upon itself, before excessive denudation removed the other sixth whose place is now occupied by the waters of the Lake of the Woods between Rabbit Point and Windy Point.

Diffuse character of Keewatin trough on S.E. coast of Lake of the Woods.

Having thus traced out, as closely as field conditions will allow, one of the limiting edges of the Keewatin belt along its line of contact with a great central, more or less circular or elliptical mass of Laurentian gneisses, we may cross the belt at any point and proceed to examine the limits of its distribution to the eastward. We may begin the tracing out of the more easterly edges of the area of the Keewatin rocks in the neighbourhood of Clear-water Lake on the Kishkutena route. Here the belt is narrowest, being not more than three miles wide in a direction transverse to the strike, which is about N.E. and S.W. In crossing the belt, from the granitoid gneiss on the one side to the same rock on the other, we pass over the upturned edges of strata which lie in a sharply folded trough. The rocks on Clear-water

Limits of Keewatin rocks to the eastward.

Clear-water Lake section.

* v. Annual Report, 1885, p. 77, cc.

Lake which occupy the middle of the trough, or the upper portion of the Keewatin series, are very largely volcanic rocks of an acid character, being mostly felsites more or less slaty and schistose, glossy sericitic schists, and felsitic agglomerates (altered quartz-porphyries and their tuffs) with, however, some more basic rocks such as serpentine and agglomerates, or conglomerates (?), in which the matrix is a green, rather massive schist and the inclusions blotch-like masses of felsite. The sides of the trough or basal portions of the series are made up of altered traps and black hornblende schists. On the east side of the trough, portions of the basal formations of the series have been removed by the disturbance associated with the irruption of the great mass of granitoid gneiss with which the belt is in contact, so that the granitoid gneiss comes against the higher formations of the series, or the middle portions of the trough. This mass of Laurentian gneiss on the east side of the Keewatin belt on Clear-water Lake will be found to be the counterpart of the large circular or elliptical mass of Laurentian gneiss described as encompassed by the Keewatin belt from Rabbit Point around by Sabaskong, Kishkutena, and Rainy River to Windy Point on the Lake of the Woods again. In general shape, dimensions and character of rocks composing it, as well as in the nature of their relations to the belt of rocks encompassing them, the two masses or areas are perfectly analagous. I shall, therefore, proceed as before to trace out in such detail as is possible the contact of the edge of the Keewatin belt with this central mass of gneiss, so that there may be no misunderstanding as to the data upon which the mapping is based, nor any confusion between what is observed fact and what conjectural. The most northerly exposure of this contact on the east side of the Clear-water is at the bottom of Sunny Cove three miles and a-half from the north end of the lake. The Keewatin series is represented at the contact by a grey felsite schist with quartz grains (altered quartz-porphyry) which, towards the contact, merges into a fine grained grey gneiss by reason of the development of biotite in plates which lie in the schist planes. The Laurentian gneiss is coarse grained, reddish to gray in color, very quartzose and only very feebly and indistinctly foliated, and in places not at all. The west and south shores of Sunny Cove are occupied by this granitoid gneiss, and also the shore of the lake for nearly half a mile south of the cove to a point directly opposite Hazy Point. South of this the shore is occupied for about one mile by the Keewatin rocks. At the contact opposite Hazy Point an agglomerate made up of a rather massive green schist matrix with blotches like felsitic inclusions comes in contact with the gneiss. This agglomerate, together with a much larger proportion of felsite schists with quartz grains (quartz-porphyries), occupies this mile of

Central schist-encircled area of Laurentian

Contact of Laurentian and Keewatin on Clearwater Lake.

Character of rocks.

shore to the entrance of Gloomy Cove, where the altered quartz porphyries come in contact with the granitoid gneiss, which is here very distinctly foliated in contrast to its more granitoid aspect at Sunny Cove. As before, when the altered quartz-porphyries approach the Laurentian gneiss the alteration becomes more and more pronounced, and they pass into fine grained, gray gneisses by the development of biotite, so that there can be no doubt but that this passage, from a quartz-porphyry to a fine grained gray gneiss, is the result of contact metamorphism, or, more generally, to a metamorphism of disturbance analogous to that which Lehmann states has produced the granulites of Saxony. From the north side of the entrance to Gloomy Cove the shore of the lake and one or two of the off-lying islands are occupied by the Laurentian gneiss, to a point on shore a mile and a-half southward, measured in a straight line. At this point, which is at the mouth of a small stream, half a mile south of Burnt Narrows, the Laurentian gneiss is again observed in contact with the gneissic modification of the altered quartz-porphyries of the Keewatin. On the west side of the lake, less than half a mile from the contact, the Keewatin rocks have been much less affected by the metamorphosing influences of the Laurentian gneiss, and consist of what are ordinarily termed felsite schists (quartz-porphyries), and felsitic agglomerate schists. All along the east side of Clear-water Lake the dip of the schists is to the east or under the Laurentian gneiss at angles varying from 70° to 80°. From the neighbourhood of Burnt Narrows on Clear-water Lake, the trend of the line of contact between Laurentian and Keewatin bends around to the south-east very sharply, in accord with a similar sharp bend in the strata of the eastern portion of the Keewatin belt, and is next seen at a point about five miles and a half distant on the shore of Lake Despair. Here a band of black-green, hornblende schists, the regular basal formation of the Keewatin, comes in between the Laurentian gneiss and the fine grained gray gneisses of the central portions of the Keewatin trough, which are presumably the alteration products of quartz-porphyries. This band of hornblende schists is well exposed on Lake Despair for a distance along the strike of two miles and a-half, and across its entire breadth. Associated with these schists at the bottom of South Bay is a considerable mass of serpentine which will be referred to again. The schists appear to constitute the true basal member of the Keewatin series. The Laurentian rocks with which they are in contact to the north-east are for the most part coarse-grained, reddish to gray, hornblende syenite gneisses, with a sparing amount of quartz and biotite, the latter often appearing to be merely an alteration product of the hornblende. The gneissic foliation is quite distinct. The dip of the schists is uniformly to the north-

Alteration of quartz-porphyry schists to gneisses near the contact of the Laurentian gneiss.

Dip of the Keewatin rocks under the Laurentian gneiss.

Bend in the trend of the rocks.

Hornblende schists on Lake Despair.

Serpentine in middle of the band.

east, or under the Laurentian gneisses, at angles varying from 60° or 65° to 70° or 75°, and the planes of foliation of the Laurentian gneiss are approximately in the same position. In its north-westward prolongation, this band of hornblende schists appears to thin out and disappear at the present surface, since they do not occur, as has been noted, at the contact of the Laurentian with the Keewatin observable near Burnt Narrows on Clear-water Lake. This thinning out is probably not due so much to an original lenticular deposition as to removal by absorption or displacement, incident to the irruption in a state of fusion of so large a mass of granitoid gneiss. With regard to the question of removal by absorption, it is interesting to note that the Laurentian granitoid gneiss on Clearwater Lake, where it comes in contact with the acid altered quartz-porphyries, is a quartzose, biotite granite gneiss, whereas, on the other hand, where it comes in contact with the more basic, hornblende schists on Lake Despair it is a hornblende syenite with, for the most part, only a small proportion of quartz. The occasional occurrence, in certain portions of the gneiss on Lake Despair of a large proportion of quartz, such as would constitute it a granite gneiss, seems indicative of an imperfect mixture.

Thinning out of schists, and its probable explanation.

Continuation of hornblende-schists of Lake Despair.

On the shores of South Bay of Lake Despair, this band of hornblende schists has a breadth across the strike of at least half a mile. In its southward prolongation from this point the band appears to curve around to the south-west, and to strike in the direction of Rainy River, in the neighbourhood of the Longue Sault, where the schists are next seen in considerable volume as already noted. In the interval between the South Bay of Lake Despair and Rainy River, however, the country is mostly covered by post-glacial deposits, and the continuity of the rocks cannot be traced.

Line of contact to the N.E. of Clearwater Lake.

North-eastward from the middle of the east side of Clear-water Lake the actual contact of the Keewatin and Laurentian has not been traced out for several miles. The distribution of the rocks on either side of it has, however, been established so well that the line can be mapped with approximate precision. The west side of the north end of Clearwater Lake and all the shores of First Quill Lake, Narrow Lake, Link Lake, and Pipe-stone Lake, are occupied by Keewatin rocks which are mostly altered traps and hornblende schists. A long ridge of these schists runs down the S. E. side of Pipestone Lake with a strike of N.-E. and S.W. This ridge is crossed at two places by depressions through which waters from the south flow into Pipestone Lake, and at each of these places the contact can be accurately located. The first of these is at Stone-dam rapids where Stone-dam Lake empties into a bay of Pipestone Lake. A short distance above the rapids the schists give place to a rather coarse-grained hornblende-syenite gneiss. This gneiss

Contact on Stonedam Lake.

is observable, with variations in composition, such as addition of a little quartz occasionally, or the presence of more biotite than usual, in continuous exposure for over twelve miles on Stone-dam Lake, Loon Lake and Jack-fish Lake to its extreme S.W. end. The line of contact between the Keewatin rocks and the Laurentian must lie between this line of exposure and the exposures of the Keewatin rocks on Clearwater, Pipe-stone and intervening lakes. The line of contact is assumed, as is generally the case where clearly observable, to be parallel to the strike of the Keewatin schists. A line drawn, therefore, from the point of contact on Clearwater Lake to that at Stone-dam rapids, parallel to the strike of the schists on Pipe-stone Lake, must be approximately the line of contact which we are endeavouring to trace out.

Contact on Creek flowing into Pipestone Lake.

The second place at which the ridge of the Keewatin schists on the south-east side of Pipestone Lake is crossed, is a little over a mile eastward of Stone-dam rapids where a small creek flows in from the south, and the point of contact is in the projection of the line just sketched, the strike of the rocks being 85°.

Line of contact skirting north shore of Kaiarskons Lake.

About four miles to the eastward, Kaiarskons Lake affords easy access to the rocks, and the line of contact of the Keewatin hornblende schists and the Laurentian gneiss is found to skirt the northern edge of the lake and to be observable at a number of points, some of which are good exposures. The first of these is at the N.W. corner of Kaiarskons Lake where a small creek flows in from the north. The Keewatin series is represented as usual by a black, glistening hornblende schist. The schists are peculiar in having imbedded in them large crystals or nodules of white altered felspar, which cause them to resemble closely the basal formation of the same series where in contact with the Laurentian gneiss on the north side of White-fish Bay, Lake of the Woods. The Laurentian gneiss is a coarse-grained hornblende-syenite of gray color. The gneiss traverses the hornblende schists in different directions, but most commonly in the direction of the planes of fission. Angular fragments of the schist are also contained in the gneiss. The general strike of both schist and gneiss is about E. and W. The Keewatin rocks extend away to the north, and the Laurentian gneisses have an extensive areal exposure to the southward.

Gneiss traversing hornblende-schists and including angular fragments of the same.

Conditions of contact farther east on Kaiarskons Lake.

Two miles farther east, in the same line, the contact is again observable on both sides of the narrows of the north arm of the lake. The hornblende schists of the Keewatin, which occupy the country to the north, are seen in direct contact with the coarse syenite gneiss of Kaiarskons Lake on the east side of the narrows. The strike of the schists is about 105°, and the dip south, or under the gneiss, at $< 80°$

The schist is traversed by small irregular dykes of the hornblende syenite gneiss which emanate from the main mass. On the west side of the narrows there appears to have been a partial fusion of the schists with the gneiss, and portions of the former are included in the latter.

About half a mile farther to the east, in the same line, at the east end of the north arm of Kaiarskons Lake, the contact can be very closely located, but not actually observed. The same statement is true of the contact half a mile still further east on the opposite shore. In both these cases the two different rocks are traceable on either side to within a very short distance of the contact, so that its location may be said to be definitely determined.

Interception of line of contact on Manitou canoe route.

Eastward of the point on Kaiarskons Lake where the contact was first noted, the line of contact curves around somewhat to the southward along the north side of the lake. After leaving the lake the line continues apparently in this same curve till it is next intercepted on the Manitou route near Cedar Narrows on Pickerel Lake. Where the line crosses the Narrows, there is very clear evidence of a fault, whereby the rocks on either side have suffered a differential dislocation in a horizontal direction of about 2000 feet, the northward thrust being on the east side, and the southward thrust on the west side of the fault line which runs N.N.E. and S.S.W. On the west side of the lake the contact between the Laurentian hornblende-syenite gneiss and the black-green hornblende schists of the Keewatin can be located within a few yards. On the east side the actual contact is visible just at the narrows. Here the hornblende schists appear to have undergone partial fusion with the syenite, and for a few yards there is a sort of transition between the two distinct types of rocks; and within the hornblende schists, distinctly recognisable as such, there may occasionally be detected large crystals of red felspar, which is quite foreign to these rocks, as if the felspathic magmas had penetrated within the schist and crystallized there in the same large crystals in which they are wont to appear in the coarse gneiss. In the belt of gneiss between this point and Rainy Lake, fragments of the black hornblende schist included in the gneiss are not infrequently met with. The strike of the schists at the contact is about 95°, and the dip at the north at $<$ 72° to 76°.

Fault at Cedar Narrows.

Apparent fusion of schists and gneiss at contact.

Inclusions of hornblende schist in gneiss.

Contact on Bat Lake.

East of Cedar Narrows the line of contact bends slightly to the northward in harmony with the northward trend, which the country to the east of the narrows has received. It is next intersected at a point three miles and a-quarter distant on the shores of the north end of Bat Lake on the Little Canoe River route. Here the Laurentian gneiss, instead of being a hornblende syenite, is a very coarse mica-syenite

with only a subordinate amount of quartz. The line crosses the lake half a mile from the portage at its extreme north end, and can be located very closely, though not with absolute precision on either side of the lake. On the east side of the bay which leads up to the portage the hornblende schists of the Keewatin have a strike of 145°, and dip N.E. at < 35°. The country to the north, which is well exposed, is occupied by the Keewatin rocks, while that to the south is Laurentian. It is this known distribution of rocks on either side of the contact line, as well as the knowledge of the precise localities at which it is intersected and observed at irregular intervals, that enables us to trace out, with great certainty, the locus of the contact of the Laurentian and Keewatin across country. The next point of intersection is on the Big Canoe River route near the lower end of Pickwick Lake. Between this point and the last noted on Bat Lake, the line of contact has apparently a N.W. and S.E. course. Just where it crosses Pickwick Lake its course is about due N. and S. and the hornblende schists, whose strike is coincident with this, dip to the E. or away from the Laurentian at angles varying from 65° to 90°. The Laurentian gneiss is a coarse hornblende syenite. The distance from the contact on Bat Lake to that on Pickwick Lake is seven miles and a-half. But the country to the north and east is accessible and known to be occupied by Keewatin rocks, while that to the south is all Laurentian gneiss, where it has been examined along the canoe routes. On Pickwick Lake the actual contact is concealed by a narrow, marshy bay on the south side of the lake, and by the forest coming down to the water's edge on the south side. The rocks on either side of the line have, however, been traced close up to the contact.

Contact on Pickwick Lake.

Contact on Big Saw-bill Lake.

Although the course of the line of contact, where it crosses Pickwick Lake, is locally N. and S., the general course, after leaving that lake, appears to be as before, N.W. and S.E., for, at six miles farther on in this direction the contact is again observed at the N.E. end of Big Saw-bill Lake. Here, however, the black-green hornblende schists of the Keewatin are not, as heretofore, in contact with a coarse syenite gneiss, but with a quartzose, biotite gneiss of much finer texture and occasionally very evenly laminated. The strike of the hornblende schists and gneiss at the west end of the portage leading to Otukamamoan Lake is about 170°; a little farther south the line bends around to a north and south curve, skirting the west side of Big Saw-bill Lake.

Shallowing out of Keewatin trough on Otukamamoan Lake.

South-eastward of Otukamamoan Lake, the Keewatin trough, one of whose edges we have been tracing, suddenly shallows out; and, although on the west side of the lake, it occupies a breadth of nearly eight miles, it breaks up on the east side of the lake and to the south-eastward of it, into three narrow tongues, so that the broad belt

appears to end abruptly in a sort of trident fork. The two more northerly of these tongues appear to taper out altogether some few miles east of the lake. The most southerly appears to be more continuous. Its south-western edge is the continuation of that which has been noted as in contact with the Laurentian gneiss on Big Saw-bill Lake. This tongue of the Keewatin belt has a breadth, measured from the south end of Big Saw-bill Lake to the south end of Otukamamoan Lake, of between four and five miles. South-eastward from this it tapers very rapidly and crosses Redgut Bay of Rainy Lake at Cliff Narrows in the form of an attenuated syncline a few hundred yards in width. This synclinal trough is but a pinched-in remnant of the basal portion of the Keewatin series. The rocks composing it are much shattered, and the underlying gneiss sends apophyses into it in various directions. Fragments of the hornblende schist also are found imbedded in the gneiss to the north and south of this attenuated phase of the belt, quite profusely. The strike of the rocks at Cliff Narrows is about east and west on the average, though it varies much locally. The dip of the schists is distinctly that of a syncline, being to the north on the south side of the band, and south on the north side at high angles. Traced still south-eastward this attenuated band of the Keewatin rocks appears to expand again and merge into the broad belt of these rocks which occupies the country between Little Turtle Lake and Seine River. In the neighbourhood of Little Turtle Lake, this belt appears to bifurcate; one branch, the smaller, striking off to the N-E. accross the narrows of the lake, and across Heron River and Big Turtle River. Where it crosses the narrows of the lake, it is much mixed with the Laurentian gneiss, which penetrates it in all directions, and which holds, in the neighborhood of the contact, great numbers of fragments of the schist whieh are generally quite angular.

Continuation of belt across Redgut Bay

Fragments of schist imbedded in gneiss.

Keewatin belt on Little Turtle Lake.

The northern edge of the other branch, the Seine River belt of the Keewatin rocks, skirts the the south shore of Little Turtle Lake, that entire shore with the exception of two miles of syenitic gneiss about the middle of the lake, being occupied by green schists. At the east end of the lake and on the north side of the lake between the Big and Little Turtle rivers, there is a band of mica-schists and fine-grained, evenly laminated gneisses between these green schists of the Keewatin and the granitoid Laurentian gneiss. These beds have a thickness of perhaps 2000 feet, and are analogous, both in petrographical characters and in geological position, to the rocks of the Coutchiching series, so voluminously developed on the south side of Rainy Lake, which they seem here to represent. Both the Coutchiching and Keewatin rocks have, at the east end of Little Turtle Lake, a common east-and-west strike, and a dip to the northward under the Laurentian

Seine River belt of Keewatin rocks

Coutchiching series.

Dip of schists under Laurentian gneiss.

gneiss of from 45° to 80°. The schists which skirt the north shore of the lake between the Big and Little Turtle rivers are much traversed by a salmon tinted rock, which has the characters of a felsite or quartz-porphyry. This rock cuts the schists in different directions, but mostly along the planes of fission. In places this quartz-porphyry assumes a distinctly crystalline aspect and shows a gneissic arrangement of the minerals. These characters become more pronounced as the Laurentian gneiss is approached, and it finally appears to merge into the latter rock, the gradation being quite analogous to that often observable at the periphery of a granite boss where the apophyses from the main mass, having cooled more rapidly, appear as fine textured porphyries.

Evidence for mapping line of contact where it is not actually traced.

Resuming again the inquiry as to the position of the edge of the Keewatin belt as it bends around at the west end of Little Turtle Lake and strikes to the W.S.W., we find that the actual contact of the basal beds with lower rocks is not easily observable for about ten miles till it appears on the north shore of Swell Bay on Rainy Lake. The mapping of the line of contact, for this interval, depends on indirect evidence. This consists of the known distribution of the Laurentian gneiss and Coutchiching schists on the shores of Redgut Bay and on Little Ottertail Lake on the one side, and on the other, the known distribution of the Keewatin rocks on Bad Vermilion Lake, Seine River, Seine Bay and Swell Bay.

Keewatin trough on Rainy Lake flanked by the schists of the Coutchiching series.

The Keewatin trough, from its northern edge on Swell Bay, one mile east of the Bear's Passage, to its southern edge on the first bay of the Seine River and north of Halleluiah Point, has a breadth of about five miles. This trough is flanked on either side by the rocks of the Coutchiching series, which dip under it, forming the floor upon which the Keewatin rocks rest, and lying between the latter and the still deeper Laurentian gneisses. At the contact of the two series on Swell Bay, one mile east of the Bear's Passage the mica-schists of the Coutchiching and the green hornblende and chloritic schists of the Keewatin have a common dip of from 60° to 75° E. 15° S., and there is no evidence of an unconformity between the two series, only a marked contrast in their petrographical characters, which is persistent througout the series. The same contact, it may be mentioned, is also observable three-quarters of a mile to the N.N.E. at the bottom of an inlet of Redgut Bay, where the direction of the common dip is 10° more to the south.

Contact of Coutchiching and Keewatin on Swell Bay.

On the south edge of the trough the contact of the basal portion of the Keewatin series, with the upper beds of the Coutchiching, is approximately observable, as already mentioned, at two places, viz.: on the shores of the first bay of the Seine River and again to the north of Halleluiah Point. At both places, the immediate contact is concealed,

but the exposed rocks on either side are only about 100 yards apart. On Seine River the lower series is represented by mica-shists and the upper by soft-green hornblendic and chloritic schists, overlaid by a thick bedded formation of scarcely schistose altered trap. The schists of the two series have a common strike of about 75° to 85°. Farther up stream the contact between the two series can be traced at a number of points, and it appears to adhere very closely to the direction of the river. The Coutchiching schists occupy the south side of the river east of Kettle Point, and the south side of the east end of Grassy Lake, while the Keewatin rocks are on the north side. The contact is crossed on the Rat River portage and farther east it runs through the middle of Wild Potatoe Lake, the Keewatin schists occupying the north shore, and the Coutchiching the south. The same is true of Partridge Crop Lake. In all of these cases the structural planes of the Keewatin rocks are parallel to those of the Coutchiching, and so far as this is indicative of conformity, the two series are conformable. But as will be pointed out in another place there are other weighty facts which indicate an unconformable relationship. The dip of the Coutchiching rocks near the contact is to the north, under the Keewatin or quite vertical. This vertical attitude is, however, only assumed in close proximity to the Keewatin trough, for, a short distance to the south, the Coutchiching rocks dip northward at low angles, and only plunge down vertically on approaching the Keewatin trough, the superincumbence of which is undoubtedly the cause of the higher angle of dip. At the contact between Halleluiah Point and Seine Bay, there are apparently no green schists of the Keewatin series between its massive altered traps and the mica-schists of the Coutchiching.

Contact of Coutchiching and Keewatin on Seine River.

Vertical attitude of Coutchiching rocks as they plunge under the Keewatin.

From the vicinity of the mouth of Seine River and Swell Bay the trough of Keewatin rocks can be traced very distinctly, in a W.S.W. direction across Rainy Lake, for a distance of about eighteen miles in a gradually tapering belt, flanked on either side by the schists of the Coutchiching series. All the islands of the lake have rocky shores and, as a glance at the map will shew, a study of these shores should afford us very much more abundant data for the mapping of the different formations than can ordinarily be obtained inland.

Course of Keewatin trough through Rainy Lake.

Along the northern edge of the trough, from the north side of Swell Bay, the contact of the green hornblendic and chloritic schists of the Keewatin and their associated bedded traps, with the mica-schists of the Coutchiching, has been traced as mapped. It runs across the southern portion of Dude Island, through the middle of Morton, Armot, Sand Point, Angling and Red Pine islands. Red Sucker, Jackfish and Stop islands and Medouganak Point, are occupied by the Coutchiching schists, while Grassy Island and the south and west shores of

Northern edge of trough flanked by schists of Coutchiching.

Rat-root Bay are occupied by the Keewatin schists. Thus the line of division between the two series on the northern side of the Keewatin trough can be mapped with great precision, although considerable portions of it are concealed by the waters of the lake.

Dip of rocks at contact.

Along this line, the dip of the rocks of the two series is the same, and is always at high angles, generally varying between 70° and 90° although occasionally 60°. The dip is very frequently reversed so that the Keewatin rocks dip under the Coutchiching. Thus on Armot Island the dip, although at very high angles, is normal, or south, and the mica-schists of the older series pass under the green schists and traps of the newer. Along the north shore of the eastern part of Sand Point Island the prevailing dip is reversed, or north, so that the newer rocks pass under the older. The dip is also reversed in the vicinity of Medouganak Point where the Keewatin schists pass under the Coutchiching at $< 60°$. For the most part the contact of the two series is one of apparent conformity, and there is even a sort of transition from the one to the other observable in many places where fissile green-hornblendic and chloritic schists are interbedded with more siliceous and micaceous ones. On the north-east end of Red Pine Island, however, a portion of the altered traps of the Keewatin which is associated with the green-schists may be seen breaking through the Coutchiching schists which abut directly upon it. On the shores of Rat-root Bay, the basal beds of the Keewatin are pebble conglomerates, of which the paste is a green schist and the pebbles mostly water-worn, rounded or oval pieces of vitreous or saccharoidal quartz. Some of the pebbles are felspathic, and when so, are occasionally foliated. On the south shore of the bay, boulders of granite are observed to form part of this conglomerate, one boulder being at least eighteen inches in diameter and of a roughly rounded shape.

Basal conglomerate.

Variation in character of basal hornblende schists of Keewatin.

It is extremely significant that nowhere along this line of contact of the Keewatin with the Coutchiching, do we find at the base of the former series those black, or black-green, eminently crystalline, glistening hornblende schists which are so prevalent at the base of that series wherever it is in immediate contact with the Laurentian gneiss. The intervention of the Coutchiching series between the Laurentian gneiss and the basal beds of the Keewatin enables us to see those beds in their least altered aspects. The eminently crystalline, black glistening aspect of these basal beds, when in contact with the Laurentian gneiss, appears to be a function of their proximity to the gneiss. This view is in harmony with many other facts which point to genetic identity of the Laurentian gneiss and irruptive granite. The rocks of both the Coutchiching and the Keewatin series appear generally to be much more altered or metamorphosed, as the contact with the

Laurentian gneiss is approached than they are in the middle of the troughs, or upper portions of the series. This gradation of alteration is analogous to the gradation in a contact zone of slates around a granite boss; and the inference, supported by many other contact phenomena, and by the almost identical character of the rocks, is that the alteration of the rocks of the Coutchiching and Keewatin series bears the same relation to the gneiss that the alteration of slates of a contact zone bears to a granite boss.

"Contact" and "regional" metamorphism.

There is, indeed, a difference in the scale on which the operation in the two cases has been, so to speak, conducted. The molten gneiss being under and around these troughs of Upper Archæan rocks, and the action long continued by reason of confinement under a superincumbent crust, the resulting metamorphism has been more intense and more general, or *regional*, than in the case of a mere local intrusion of granite through higher portions of the crust. But while the metamorphism has been regional, it has been more intense at the actual contact of the basal portion of the firm crust with underlying magmas than in higher portions of the series of formations, and in this gradation of results we have distinct analogy with "local" or "contact" metamorphism, so called. The conception of the igneous origin of the Lower Archæan or Laurentian and the metamorphic character of the Upper Archæan, thus explains very satisfactorily why the basal beds of the Keewatin, where it rests on the Coutchiching, should not be similar to those same beds when resting on the Laurentian, and why, in the latter case, those beds should appear much more altered than in the former.

Southern edge of Keewatin trough flanked by schists of Coutchiching series.

The southern edge of this Keewatin trough which stretches, as sketched, from the Seine River across Rainy Lake to Rat-root Bay, cannot be traced out so satisfactorily as the northern edge, for the reason that it is mostly concealed by the waters of the lake. At the mouth of Black Bay, however, the line of division between the two series, Keewatin and Coutchiching, can be located with comparative precision; and, as the rocks on Grind-stone, Dry-weed, and numerous other smaller islands between the last of these and Halleluiah Point, are well exposed, the distribution of the rocks of the two series is not a matter of doubt. The south shore of the lake from the west side of the entrance to Black Bay to the bottom of Rat-root Bay is a continuous exposure of Keewatin rocks, and affords a section across the trough diagonal to the strike. In this section it is seen to be flanked on either side by the mica-schists of the Coutchiching series.

Continuation of Keewatin trough on S. side of Rainy River conjectural.

Any attempt to follow up this belt of the Keewatin rocks from Rat-root Bay, W.S.W. in the direction of the strike is baulked by the thick blanket of post-glacial formations which conceals the greater part of

the old rocks, and by the absence of any means of access to the country whereby occasional exposures of them might be noted.

Outcrops of Keewatin rocks on Rainy River.

About twenty-five miles distant, however, in the line of the strike, Keewatin rocks belonging probably to this same belt are observable in two or three small exposures on Rainy River. The first of these I have not seen myself, but I am reliably informed that the Indians quarry pipestone from a small patch of green rock that projects through the soil on the river road just at the bend of the river in tp. 6, S., R. XXVIII. Such pipestone is only found in the Keewatin rocks in this region. Farther down the river, in the next township of the same range, I have observed two exposures of hornblende schists, one on either side of the river, and at some distance from its banks. In both instances the reason of this projection of the rocks above the level of the fresh water deposits which cover the country is the protrusion of a trap dyke. That on the American side affords access to a considerable body of hornblende schists which have a vertical attitude and a strike coincident with the direction of the river at this place. The one on the Canadian side reveals only a few small patches of hornblende schist adhering to the side of the dyke, but still quite sufficient to indicate the character of the country rock through which the dyke has cut.

Laurentian and Coutchiching rocks on Rairy River.

These exposures, limited as they are, give us a very satisfactory clue to the structure of the country if they are considered in connection with other facts. The strike of the belt would appear to curve around to the N.N.W., as is further suggested by the sharp bend of the river. In so bending, the belt curves around an area of Laurentian hornblende syenite gneiss which is exposed on Mr. Singleton's farm, tp. 5 S., R. XXVIII, Sec. 8 and 9. From this syenite gneiss it appears to be separated by a band of fine-grey bedded gneiss which is thus analogous petrographically and in geological position to the Coutchiching series of Rainy Lake, though here apparently the series is very much diminished in volume. The exposure at which this fine-grained grey gneiss is seen, on an island about four miles above the Manitou Rapids, indicates that the rocks, again in harmony with the bend of the river curve around to the west, this time probably around an area of granitoid gneiss on the south side of the river, of which there is an exposure at the foot of the Longue Sault Rapids. If the belt of the Keewatin rocks, which we have been tracing, thus curves around here, as all the evidence at our disposal indicates, it must merge into the expansive belt already noted on the Longue Sault Rapids, in the country to the north of it, and on Pine River.

Probable disposition of the rocks beneath the post-glacial formations.

Thus in following up this belt of Keewatin rocks, and tracing out its inner edge, or line of contact with underlying rocks, we find that it forms a complete circuit. From Lake Despair around to

Rat-root Bay by far the greater part of this circuit has been traced in detail. For the portion that is concealed by the post-glacial deposits of the Rainy River country, such outcrops as can be found, together with the other evidence cited above, all point to its unbroken continuity, by way of the Keewatin area north of the Longue Sault, with the greater portion which has actually been traced out. This circuit embraces a great central area which is made up almost entirely of Laurentian gneiss, between which and the Keewatin rocks of the south part of Rainy Lake, there intervenes, however, a comparatively small area of rocks of the Coutchiching series.

The Keewatin rocks traced in in an almost complete circuit embracing a central area of Laurentian.

It now begins to be apparent that a very general areal disposition of the Laurentian gneiss, with reference to the rocks of the upper Archæan, is that of central, circular or oval areas, begirt with a continuous belt of those rocks in the shape of a sharply folded trough.

General relative disposition of Laurentian and upper Archæan rocks.

In the report of 1885, on the Lake of the Woods, one of these areas of gneiss, that comprising the Grande Presqu'ile and White-fish Bay, was described, and the inner edge of the encircling belt of Keewatin rocks defined. In the earlier pages of this report it is shewn that the Laurentian gneiss of Sabaskong Bay and the country to the southward constitutes another of these central areas, also encircled by the Keewatin rocks. And now it has just been indicated that the Laurentian country to the north of Rainy Lake is another, the confines of which as limited by the inner edge of the encircling Keewatin trough have been traced out in detail. There will be frequent occasion to refer to these areas and the most convenient way to do so is by name. The first of these may be called the Obabicon area, from the lake of that name in its central part; the second, the Sabaskong area; and the third, the Stanjikoming area.

Different Laurentian areas named.

The belts of Keewatin rocks which encircle these different areas are all anastomosing or confluent. They form a continuous retiform area, the meshes being occupied by the Laurentian gneiss. At their nodes, or points of confluence, these belts have their greatest width. Elsewhere they are generally narrower, and at times extremely attenuated.

Confluence of encircling belts of Keewatin series.

These three prominent central areas of Laurentian gneiss are not the only ones. If we cross the belt which encircles the Stanjikoming area at its narrowest points, we come upon other schist-encircled areas of gneiss besides the Sabaskong area which lies to the west of it. Some of these cannot be mapped with any degree of precision, on account of the covered character of the country; others extend beyond the limits of the region examined, and can only be partially mapped on the sheets now published. Some of these, however, of subordinate importance, are within the limits of the region mapped. Thus on

Other central or nuclear areas of Laurentian.

Minomin Lake and Lake Despair on the Kishkutena route, there is exposed an area of biotite gneiss of varying texture which is certainly partially and probably wholly surrounded by Keewatin rocks. This area is of comparatively small extent and occupies a position intermediate between the Sabaskong and Stanjikoming areas. It may be referred to as the Minomin area. As has already been noted, evidence was observed of another of these Laurentian areas on the south side of Rainy River in the vicinity of the Longue Sault Rapids, but the country is so covered that it would be hopeless to attempt to determine its extent.

Minomin area.

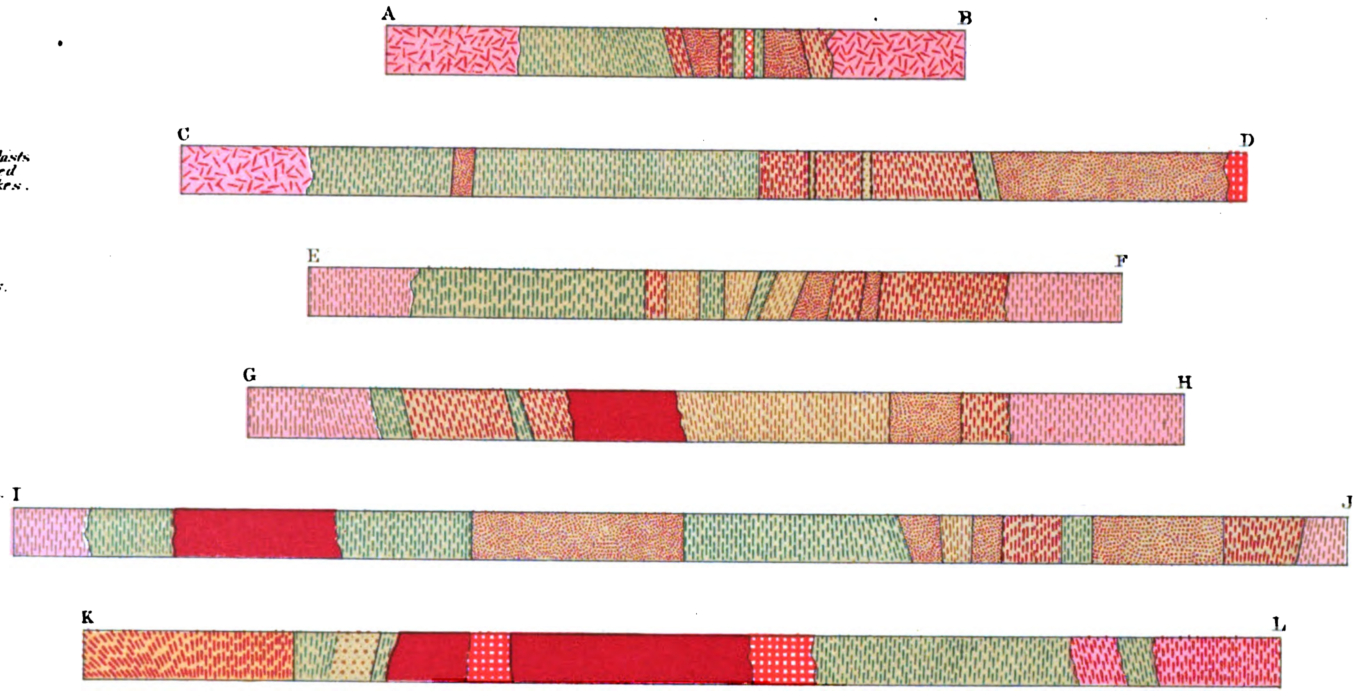
A course of five miles in a northerly direction from the southern edge of the Keewatin belt, on the north side of Kaiarskons Lake, takes us across the entire width of the belt at this point, at right angles to the strike of the rocks; and we come upon another area of Laurentian rocks. Only the southern portion of this last area comes within the limits of the Rainy Lake sheet. Its contact with the Keewatin rocks has, however, been accurately determined on Harris, Missus and Bluff lakes. The rocks of this Lake Harris area are granites and syenites, in which a gneissic structure is in places almost entirely wanting. The mass is regarded provisionally as the equivalent of the Laurentian gneisses of the Stanjikoming area to the south of the belt. The Keewatin rocks in contact with it are not those of the base of the series, but those of its upper portion, usually observed to occupy the middle of the trough. They are chiefly felsites and felsitic schists, most of which appear to have been quartz-porphyries or their tuffs. The irruptive character of the granite as observed at its contact with those felsites, and felsitic schists is inferred from the dykes or apophyses which ramify from the main mass into the surrounding rocks. When the contact of the granite and schists is observed on the north-west side of Lake Harris about its middle, the schists are much cut by such dykes. From this point, south-westward, the whole of the north-west side of Lake Harris is occupied by granite, while the south and south-east shores are occupied by felsites and felsitic schists, followed to the south-east, across the strike, by felsitic agglomerates. The greater part of the shores in the north-east portion of Missus Lake are granite, while in the south-western portion, the felsitic schists occupy one shore and the agglomerates the other, as mapped. The north shores of the two small lakes to the south-west of Missus Lake are occupied by felsitic schists more or less glossy and sericitic.

Lake Harris area.

Irruptive character of Laurentian.

On Bluff Lake the line of contact between the Laurentian and these same felsites and felsitic schists, crosses the lake about one-third of its length from its outlet, the two rocks being very much mixed along the contact.

Contact on Bluff Lake.



Diagramatic sections across Keewatin trough along the lines indicated on the accompanying map.
Scale: ¼ inch to 1 mile.

If we follow eastward that portion of the Keewatin belt, whose narrowest section is north of Kaiarskons Lake, we find that it rapidly expands and eventually bifurcates into two arms which embrace still another, and apparently very extensive, area of Laurentian gneiss. One of these arms trends to the south-east and bifurcates again in the vicinity of Little Turtle Lake, as has already been described. The other strikes north-east and has been traced, along the shores of the Manitou canoe route, as far as Wabigoon, probably, however, with several lateral ramifications in the interval. The contact of the eastern edge of the Keewatin belt with this Laurentian area which occupies the north-east corner of the Rainy Lake sheet, from the lakes of the Otukamamoan route across to the Big Turtle River, has been fairly well traced within the region mapped. This line crosses Windigons Lake near the north end of the two arms into which it is divided. It next crosses Smooth-rock Lake near its south end. The Keewatin rocks are in both instances black hornblende schists, and the Laurentian coarse granitoid gneiss, which varies in composition from that of a hornblende-syenite or a hornblende-granite to ordinary biotite-granite. From the south end of Smooth-rock Lake, the line of contact has not been closely traced but is known to lie to the west of Kahops-kikamak Lake and Sakwi-té Lake, the shores of both of which are occupied by Laurentian gneiss. The line of contact of the two rocks is next observable on the west side of Otukamamoan Lake, where there is the clearest possible evidence of the rapid thinning out or shallowing of the Keewatin trough and its breaking up into tapering terminal tongues. The disposition of the rocks as mapped on the shores of Otukamamoan Lake has been accurately determined.

Tuttle Lake area of old Laurentian.

Contact of Keewatin belt with this area.

An isolated synclinal trough of the Keewatin schists, cradled, so to speak, in the Coutchiching schists, which are in turn flanked by the Laurentian gneiss, stretches from Gash Point to Redgut Bay, near Grassy Portage. The patch calls for no special description, its relations being the same as the Keewatin elsewhere in the region.

Isolated trough of Keewatin rocks cradled in schists of Coutchiching.

Stratigraphical Relations and Structure of the Rocks of the Keewatin Series—Sections.

Having sketched briefly the limits of the distribution of the rocks of the Keewatin series and pointed out their disposition relatively to the underlying rocks, we may now consider the stratigraphical composition of the series. It was found that it is usually disposed in a sharply folded trough sinking down into the gneiss which flanks it on either side. I have selected for discussion a number of lines of section where the whole series so far as represented is exposed. The first of

Stratigraphical composition of Keewatin series

these sections is that afforded by the shores of Clear-water Lake and the lakes of the Little Kishkutena route. It is represented on the map by the diagramatic section A–B.

Section A-B across Clear-water Lake.

The ridge of altered traps and green schists, which has been traced from Kishkutena Lake south-west to Little Kishkutena Lake, and thence to Off Lake, has a breadth across the strike of a mile and a half on the line of section. On the north-westward edge of the ridge at the contact with the Laurentian gneiss, is the massive porphyritic altered trap described as Sec. 1892, p. 72. Occasionally it is schistose, but for the most part on Little Kishkutena Portage, Box and Burnt lakes, it is difficult to detect either bedding or schistosity. Such schist planes, as are observable, seem to dip to the north-west or under the gneiss at high angles. On Panorama Lake, those massive traps give way to much more schistose greenstones and green hornblende schists. These strike with the long axis of the lake or N.N.E. and the dip of the schists, always at very high angles, is sometimes in one direction and sometimes in another. On the line of section, these green schists and schistose greenstones are seen on the west side of Clear-water Lake to be followed by a comparatively narrow band, somewhat less than one-eighth of a mile across the strike, of felsitic schists with quartz grains (quartz-porphyries). This band, like many others of the same or similar rocks, is non-persistent or lenticular. To the north, both this band and the next succeeding band of agglomerate schists taper off rapidly, and do not appear at all in a parallel section across Narrow Lake from Kishkutena Lake to First-quill Lake, only more or less schistose altered traps and hornblende schists being found in the section, the present surface being doubtless below the line at which may be found, the inpinched remnants of the upper portion of the series. To the southward this band of felsitic schists also thins out rapidly, for on the west side of Cedar Lake the green schists of Panorama Lake are in contact with the next succeeding band of agglomerate schists.

Details of section—character of different strata and their distribution.

These agglomerate schists constitute a wide band, tapering to the north east and expanding to the south-west, which occupies the west side of the wide portion of Clear-water Lake, with the exception of Hazy Point. All the shores of Cedar Lake and of the two small lakes to the south-west of it are occupied by these same agglomerates. The agglomerate is throughout highly felspathic, although in places it is also very largely hornblendic or chloritic. The paste is usually very similar in aspect to the included fragments and often grades into glossy sericitic, felsitic schists, being undoubtedly the ash or tuff of an acid volcanic ejection, the massive phase of which is the quartz-porphyry. The included fragments are usually lenticular where the rock is very schistose as a result of pressure deformation, but often they are quite

Agglomerates.

angular, sometimes rounded or boulder-like, but not apparently in this case smooth or water-worn, like the pebbles of true conglomerates found elsewhere in the series. On the line of section, this band of agglomerates has a width three-eighths of a mile. To the north-east it thins out and disappears in less than three miles and a half. To the south or south-westward it expands so that at a distance of three miles, on a section across the south end of Cedar Lake and the south end of the wide portion of Clear-water Lake, where the rocks are well exposed, it has a width of a mile and a half. Two miles still farther to the southward on the shores of Off Lake, the coarse agglomerate character of the rock has wholly disappeared and we have nothing but the paste, the felsitic ash or tuff, minus the included fragments of large size. This pyroclastic, felsitic rock is schistose in varying degree and where coarser-grained, a very distinct gneissic arrangement of the minerals has been induced by pressure, and accompanied by the development of secondary mica. The fragmental origin of the rock is, however, apparent, particularly in microscopic sections.

All these agglomerate schists on the west side of Clear-water Lake, have a strike 30° to 45°, and the dip is either vertical or to the S.E. at angles not less than 75°.

Felsitic schists.

On Hazy Point they are followed to the east by a considerable breadth of felsite and felsitic schists, which evidently thin out to the north, and on the line of section have a breadth of probably less than one-eighth of a mile.

Hornblende schists.

These schists do not appear at the north end of the wide portion of Clear-water Lake. The agglomerates are here followed by a band of green hornblendic schists which have a strike 25° to 30°, and a vertical dip. Only a small out-crop of these green schists is exposed. They are followed immediately to the east by a band of massive serpentine, which occupies the west side of the lake for a distance of a mile southward from the 49th parallel of latitude. Though not by any means a continuous band this massive serpentine appears to occur with some degree of constancy in the middle portion of the Keewatin trough. On South Bay of Lake Despair a mass of serpentine is found in quite an analogous position to that occupied by the serpentine of Clear-water Lake. They are, probably, the altered remains of olivine rocks which were formed antecedent to the folding of the Keewatin rocks, though irruptive through them. The Clear-water Lake serpentine is flanked on the east by another band of green hornblendic schists and altered traps observable on Pot Island. This appears to thin out to the south and is not visible on the islands or shores of the south part of the lake. It is followed to the east by a coarse, blotchy agglomerate schist, of which the paste is a green hornblendic

Serpentine.

Blotchy agglomerate schist.

schist, and the included fragments, masses of a yellowish-white or grey felsitic rock. The lines of demarkation between inclusion and paste in these agglomerates is vague, it being difficult to say where one begins and the other ends. This agglomerate occupies the shore for about a mile north of the entrance to Sunny Cove. Still to the east of this we come upon another band of felsite and felsitic schists about a quarter of a mile in breadth. These schists occupy the north side of Sunny Cove and the south side of the bay, a mile and a-half to the north of it. They also occupy about a mile of the shore between Sunny Cove and Gloomy Cove, and are observed again on both shores of the lower part of Clear-water Lake, south of the Narrows. To the east they are in contact with the Laurentian gneisses of the Stanjikoming area; and we have thus completed the section across the belt. The full complement of bands of rocks necessary to fill out the structure of the ideal trough is lacking along the line of section. The basal member of the series is not present on the east side. To the north-east of Clear-water Lake it is present in considerable volume, and also to the south-east, where the belt curves across to Lake Despair. The absence of the basal hornblende schists and altered traps is not to be ascribed to their primitive non-existence, but more probably to their removal by the disturbances which brought the granitoid gneiss in contact with the Keewatin rocks in their present folded state. One of the means of removal in the process of such disturbance, would be absorption by fusion, but to what extent the agency has been at play, would be difficult to say. There are not wanting evidences that it has played a very important part.

Felsite schists.

Incompleteness of section.

Lenticular character of formations.

From what has been said of the section across Clear-water Lake, it is apparent that on account of the very marked lenticular character of some of the formations, particularly the agglomerates and felsitic schists, that no two parallel sections would exactly correspond. The agglomerates and felsites, though separable petrographically, so wedge themselves one within the other, that they must be regarded here as forming together a single geological formation; an intimate genetical relationship being indicated by their petrographical characters.

Interpretation of section.

If thus regarded, the actual surface section, which I have described as nearly as it can be ascertained, will bear the simple interpretation shewn in the colored diagramatic section A-B, viz., that of a trough composed of a twice-folded series of two members, a lower or basal one made up of altered traps and green hornblendic schists, and an upper made up of felsitic schists (quartz-porphyrics and their tuffs) and agglomerates.

Section C-D. across Kahtimiagamak Lake to Crow Lake.

The second line of section selected, C-D, is one drawn northward from a point north of Kishkutena Lake across Kahtimiagamak Lake and the south-east end of Crow Lake. The section does not take in

more than probably half of the breadth of the Keewatin belt. In its main features it is very analogous to the Clearwater Lake section. It is interesting chiefly as shewing the great width across the strike of the component bands of the belt. Thus the mapping of the band, which comprises the basal member of the Keewatin series, as inferred from the exposures on Kahtimiagmak Creek and Lake, Night-hawk Lake, the south shore of Crow Lake and the west side of Pipestone Lake gives it a breadth of very little less than five miles, the schists being all in a vertical or nearly vertical attitude. The bedding, wherever it can be detected, as it frequently can, is also in vertical attitude. If we take into consideration, however, the enormous jamming together which the rocks have undergone, we can easily imagine as a result the complete parallelism of all the structural planes, affording a false appearance of a continuous section at right angles to the planes of deposition. Hence, it does not seem safe to infer much from the five-mile section of altered traps and green schists as to the original normal thickness of this member of the Keewatin series. It is evident, however, that such thickness must have been enormous. On Kahtimiagamak Lake, moreover, massive or only slightly schistose altered traps in which bedding can be detected only with much uncertainty, preponderate very much over the more distinctly bedded schists; and it is questionable whether these rocks, which shew little or no schistosity, and which occur in great masses, ever have been up-tilted so as to afford a section across their edges. Associated with the green hornblendic schists on Kahtimiagamak, are a few attenuated lenses of agglomerate schist and of greenish-grey felsitic schist with clear quartz grains. These beds are too small to permit of mapping on the scale adopted, but their intercalation with the various beds of green schists, and the bedding of the latter themselves, show that the rocks are in a vertical attitude. But the pressure which would effect the up-tilting of these beds might be inadequate when brought to bear upon a great mass or thick lens of tough crystalline diabase; and the more thinly bedded rocks might be simply crushed into vertical attitude against such mass. Considerations such as these render it unsafe to advance any figures for the thickness of these green schists and traps, based on the measurement of such a section.

Attitude of rocks.

Enormous thickness of basal portion of Keewatin series

True thickness cannot be safely inferred.

This band is followed to the north on the shores of Crow Lake by a wide band of bedded felsites, and felspathic grau-wackes with other clastic rocks, among which there appear some quartzites. The rocks composing this band are continuously exposed on the south shore of Crow Lake in a line oblique to the strike from Patch Island to a point within a mile and a half of the extreme east end of the lake. The rocks along this line of exposure have a general strike of 90° to 110°,

Beds of felsites, grau-wackes, quartzites.

and a prevailing dip to the northward at angles nowhere less than 75°. From the evenly bedded and quite uncrumpled condition in which the rocks are here observed, I am persuaded that there is no duplication in the section, and that the width of the band, corrected for the dip, gives the actual thickness of the formation. The width of the band, as near as can be estimated on the line of section, is about two miles, and a small deduction from this to correct the angle of dip gives us as the thickness of this member of the series 10,200, or say, 10,000 feet. To the westward, in the vicinity of Patch Island, this band appears to thin out very rapidly, and to give way to the agglomerates which occupy Chase Point and the adjacent islands. To the eastward on the shores of Schist Lake and the northwest end of Pipestone Lake, the felsites and grey-wackes which constitute the band on Crow Lake are thickly intercalated with formations of soft, very fissile, greenish grey, more or less glossy schists, which as they do not appear at all on Crow Lake must be presumed to thin out rapidly in that direction as lenses. Some of these very fissile schists are quite nacreous and are apparently only more schistose phases of altered quartz-porphyries and their tuffs, while others are associated with their local beds of pebble conglomerate, and are in places charged with dolomite which, however, appears to be a segregation and not a bedded deposit. Eastward from Schist Lake these finely fissile, grey, glossy schists are very persistent, the distinct clastic varieties prevailing. They will be noted in succeeding sections.

Thickness of band.

Other intercalated rocks in same band.

Agglomerates of Crow Lake.

On the line of section C–D the band of felsites, felspathic grey-wackes and quartzites is followed to the north by a broad band of coarse, well characterized felspathic agglomerates. The greater part of the basin of the south arm of Crow Lake appears to have been excavated in this band of agglomerates. The extreme west end of the lake affords a splendid section across the whole width of the band. Its width here, transverse to the strike, is two miles and a half in continuous exposure. Westward along the basin of the lake the same rocks are well exposed on Shanty Point, Chase Point and Line Point as well as on the numerous islands between the north and south shores of this arm of the lake. In its eastward prolongation this band appears to thin out and give way very largely to the felsites and grey-wackes which prevail on the shores of Yoke and Buff lakes. These agglomerates as seen on Crow Lake are mostly of a light greenish yellow or grey color. They are usually schistose, with the inclusions of lenticular shape all lying with their greater planes parallel. Not infrequently, however, no schistose structure has been developed in the rock and the inclusions are not at all lenticular, but sharply angular. Instances of the latter variety are prominent on the Boulder Portage where the paste is a non-schistose,

greenish-grey fragmental rock (pyroclastic) of rather fine grain, and the inclusions are sharply angular blocks of a light greenish yellow or dirty white felsite.

What relationship exists between the present breadth of the band, viz: two miles and a half in a direction transverse to the strike of rocks in a nearly vertical attitude, and the original normal thickness of the formation is uncertain. But to me it seems difficult to avoid the conclusion that this measurement, enormous as it is, represents approximately the actual thickness of the formation. Thickness of agglomerates.

This band of agglomerates is followed to the north on the line of section by a mass, the extent of which is yet only partially known of a coarse gabbro which crops out at intervals behind the agglomerates on the north shore of this arm of the lake for a distance of about four miles. This gabbro appears to have been irruptive through the agglomerates, but probably antecedent to the time of the folding. It is much decomposed, and in places quite altered to serpentine. Two small patches of serpentine which occur farther west, one on Slim Point and one on Line Point, are very probably genetically associated with this gabbro. Gabbro.

The two following sections traverse that portion of the Keewatin belt which is pinched in between the Stanjikoming area of Laurentian gneiss and the Lake Harris area of the same rocks. The complete trough does not appear to be represented, since the rocks of Lake Harris break through the Keewatin in such a way as to bring the gneiss or granite, for it is often devoid of foliation, in contact, not with the base of the Keewatin series, but with its upper portion.

The line of section E–F from the narrows of Kaiarskons Lake to Bluff Lake shows a sequence very analogous in its general features to those revealed by the sections A–B and C–D. At the base of the Keewatin series at the narrows of Kaiarskons Lake, black hornblende schists in nearly vertical attitude, in contact to the south with a broad area of hornblende-syenite gneiss, which at the immediate contact is mixed with the schist. The observed strike of the schists at this point as already noted is a little south of E, and the dip is to the south or under the gneiss at an angle of 80°. Farther north on the shores of Furlonge Lake the schists are green rather than black, and altered traps more or less schistose are prevalent. From the exposure at the north end of Kaiarskons Lake, and on the shores of Furlonge Lake, Pipestone Lake, Sucker Lake and Manitou Lake, all of which are very satisfactory, it is inferred that this band of hornblende schists and other green schists, with their associated altered traps, has a breadth on the line of section of about two miles and a quarter. It is possible that the felsite schists which are represented on Pickerel Lake to the eastward by a broad band, and on Pipestone Lake to the west- Section E-F. From Kaiarskons Lake to Bluff Lake. Thickness of hornblende schists.

ward by a very narrow band, may be continuous through the lower end of Furlonge Lake. If so, it must be very meagerly rêpresented, and as I did not observe such rocks, I have mapped the band as discontinuous. A small boss of serpentine occurs in the green schists at the southwest end of Sucker Lake; it is associated with a mottled greyish-white saussurite gabbro. The actuàl contact of this serpentine and gabbro with the surrounding schists is concealed, but there is little doubt of its irruptive character. With relation to the other rocks of the belt, it occupies a position analogous to the other bosses or patches of serpentine, (and gabbro) already noted on Lake Despair, Clear-water Lake and Crow Lake. These bosses of altered basic, massive rocks have a coarse granular texture when not altered to serpentine, or when so felspathic as to alter to saussurite. They seem to have been irruptive through portions of the Keewatin series prior to their folding, and not improbably represent the cores of vents from which were extravasated the more basic portions of the Keewatin series.

Serpentine—analogous in position to other bosses of serpentine.

Felsite schists.

Following the green schists and altered traps on Sucker Lake is a narrow band of glossy or nacreous sericitic felsite schists with clear quartz grains (altered quartz-porphyries). This band is doubtless continuous with the more extensive development of the same rocks south of the mouth of Strawberry Creek on Pipestone Lake, and with the band that crops out on the west side of Pickerel Lake just to the south of the granite boss, which there interrupts the strata. The exposure on Sucker Lake is a small one, and from the known occurrence of other rocks on either side of it, the band must be a narrow one where it crosses the lake.

Soft grey fissile schists.

Following this is a band, a mile and a half in breadth, of soft, grey, fissile schists with which are intercalated at least two small subordinate bands of green-chloritic and hornblendic schists. This band is a rather persistent one, the rocks composing it being continuous with the similar rocks already alluded to on Schist Lake and the north part of Pipestone Lake. They are traceable also eastward on Pickerel and Manitou Lakes and on the west side of the latter lake, through to Grant Lake as far as the limits of the region mapped. The rocks composing it are probably mostly altered sediments, silts and clays derived from the erosion of volcanic rocks. The occasional occurrence of beds of pebble conglomerate proves their clastic origin, and other portions of them merge into schists, which are little more than slightly micaceous fissile clay-slates. On Strawberry Lake, these schists are, as near as possible, in a vertical attitude and strike E. and W,

Agglomerate schists.

They are followed, on the north side of Strawberry Lake, by a band of agglomerate schists. At the west end of the lake this band has a

width of half a mile, but apparently thins out before reaching the Yoke Lake portage from Pipestone Lake. To the eastward it is very probably continuous with the band of the same agglomerates so extensively developed on the south side of Harris and Missus Lakes.

At the mouth of the Bluff Lake Creek, and for a mile and a-half to the northward, the only rocks observable on the creek and on the shores of Bluff Lake are rather massive, whitish or yellowish-grey felsite, sometimes pinkish to greenish tinted. This felsite is a distinct agglomerate for a short space on the creek, and seems to constitute a band which is probably continuous with the more voluminous formation of the same agglomerates on the north-east arm of Yoke Lake. At the south end of Bluff Lake, as the contact with the Laurentian rocks is approached, these felsites become more schistose, and by the development of mica along the planes of schistosity assume a gneissic aspect. The Laurentian rocks near the contact are very basic and may, perhaps, be classed with the gabbros. The schists are cut by this gabbro in all directions. Away from the contact along the almost continuous exposures of the shore to the northward, the Laurentian rocks are observed to merge gradually from the basic or gabbro variety into the acid or granite. The gabbro passes first into a hornblende-syenite gneiss of coarse granitoid aspect with, besides the orthoclase, a good deal of triclinic felspar. The quartz appears gradually a little at first, and then more and more, till at the extreme north end of Bluff Lake the rock has the characters of a very quartzose-hornblende granite, very distinctly gneissic in some places, in others much less so, and properly a granite.

Character of Laurentian near contact.

The next section G-H is along a very satisfactory line of exposure extending from the south end of Pickerel Lake along the west side of that lake, across the lower end of Manitou Lake to Missus Lake. The first interesting feature observable on the line of section is the fault of 2000 feet at Cedar Narrows which has already been alluded to (*ante* p. 33).

Section G-H. From Pickerel Lake to Missus Lake.

At the contact with the Laurentian syenite gneiss, the base of the Keewatin is, as usual, represented by a band of black hornblende schists, with a strike nearly E. and W., and a dip to the north of 72° to 76°. The band has a width on the west side of the narrows of a-quarter of a mile transverse to the strike. The fault, with its northward trend on the east side, makes these schists abut squarely upon the Laurentian syenite gneiss which occupies the east side of the narrows. These hornblende schists are followed by a band, one mile in width, of felsite schists (altered quartz-porphyries). The effect of the Cedar Narrows dislocation is still distinctly perceptible since the lower portion of these felsitic schists on the west side of the lake abut directly upon the continuation of the basal hornblende schist band on

Fault.

the east side. This dislocation probably owes its origin to the same disturbance which resulted in the protrusion of the two granite masses on Pickerel Lake, and the larger one to the south of Bat Lake. The dislocation in its north-eastward continuation is probably represented in the present topography by the basin of Manitou Lake which is a long, narrow, deep trough.

Felsites or altered quartz-porphyries. The band of felsites (altered quartz-porphyries) which occupy both sides of Pickerel Lake to the north of the narrows seems to have the form of a lens whose thickest part is on the line of section. Though having the width of a mile on Pickerel Lake, the rocks comprising it do not appear on Furlonge Lake, three miles to the west, nor on Three Island Lake about one mile to the east. On the west side of the lake the schists have a very uniform strike of 90° to 100°, and a northerly dip of from 75° to 80°. On the east side of the lake the strike is less constant, varying from 80° to 115° with the same northerly dip.

Hornblende schists. The next rocks met with going north along the line of section are green hornblende schists. These form a narrow band about one-eighth of a mile across, observable on the west side of the lake. The schists strike E. and W. and dip N. < 70°.

Second band of felsites. These are followed by another band, half a mile wide, of felsite schists precisely similar to those of the first band described. This band also is apparently very lenticular. It does not appear on the shores of the lakes to the east of Pickerel Lake, and if it is continuous to the westward, as I suppose, as far as Sucker Lake, it has, at the latter place, a very limited breadth. This band is interrupted on both sides of

Granite bosses of Pickerel Lake. Pickerel Lake by two distinct bosses of granite. That on the west side is shewn on the line of section G-H. Its exposed extent on the shore of the lake is about one mile. The boss of similar granite on the east side of the lake has its area better defined. Its greatest diameter is about one mile and a-quarter.

Clastic rocks. To the north of these granite bosses on Pickerel Lake is a broad band of clastic rocks, which occupy the shores of the north end of Pickerel Lake, and the lower end of Manitou Lake. This band has a known width of over a mile, and, according to estimates based on the disposition of the rocks on Strawberry Lake, Grant Lake and Missus Lake, its full breadth is placed at about two miles. At the north end of Pickerel Lake, the rocks are fine-grained grau-wackes or grits of dark color. Farther north, towards the rapids between Manitou Lake and Pickerel Lake, these become finer grained and pass into schists at the rapids, which are scarcely distinguishable from bluish clay-slates, though they are somewhat micaceous and distinctly schistose. The schists have a strike varying from 80° to 115°. The dip is either vertical or to the northward at high angles as far as the south shore of

Manitou Lake. On the north side of Manitou Lake, at the lower end, the dip is southward at angles varying from 70° to 90°, and the rocks here are less of the character of clay slates or grey-wackes and more of the character of greenish-grey ash beds with some thin beds of felsite schists, nacreous and glossy, and an abundance of soft, glossy, grey, fissile schists. The latter are, as has been shewn, abundantly represented to the westward on Strawberry Lake and Sucker Lake on the line of section E-F, and the same band appears to be persistent up through Grant Lake.

Agglomerate schists.

The next band of rocks which the line of section intersects is that of the felsitic agglomerate schists so voluminous on Lake Harris. At the north-east end of the latter lake, and at the middle part these agglomerates have a width transverse to the strike, of over a mile. They are well exposed on the south side of Missus Lake and appear, apparently much diminished in volume, at the east end of Strawberry Lake.

Felsitic schist.

Between these agglomerates and the Lake Harris Laurentian area is a band of felsitic schist which, on Manitou Lake, has a breadth of not more than a quarter of a mile. The section, as a whole, is remarkable for the comparatively small proportion of hornblende schists and altered traps which it reveals. In its general features, however, it is quite in harmony with the other sections already detailed.

Section I-J. from Smooth-rock Lake to Lake Harris.

The next section, that on the line I-J, crosses the Keewatin trough where it forms a wide belt, striking along the course of Manitou Lake, just before it bifurcates into two portions embracing the Stanjikoming area of Laurentian gneiss. That portion of the section which lies on the N.W. side of Manitou Lake is much better known than that on S.E. side.

Hornblende schists.

The eastern edge of the belt which strikes up Manitou Lake is intercepted at the points mapped on Windigons Lake and on Smooth-rock Lake. At the south end of the latter lake, the hornblende schists have a breadth westward across the strike from their contact with the Laurentian gneiss of over one mile, the rocks being, as usual, in a nearly vertical attitude. Here a mass of granite devoid of foliation projects through the schists. It presents a contrast to the Laurentian gneiss of the northern portion of Smooth-rock Lake in composition as well as in structure, it being a quartzose biotite-granite while the gneiss inclines more to the habitus of a syenite. The mapped area of this granite mass is inferred from its outcrop on Smooth-rock Lake. From the south end of Smooth-rock Lake across to Manitou Lake the rocks have not been actually traced on the line I-J, but their distribution is inferred from the exposures on the shore lines of the neighboring lakes. It is presumed that the hornblende schist surrounds the granite mass above mentioned on the west side as well as on the east.

Granite of Smooth-rock Lake.

Agglomerate schists.

The most interesting feature of the section on the S.E. side of Manitou Lake is the triangular area of agglomerate schists which occupies the middle portion of the trough just at the bifurcation of the belt. These agglomerates are prevailingly of a light yellowish-grey color, being mostly felsitic in composition. They are well exposed on Dog-fly and Vista lakes and on the canoe route between them. The area tapers off in three directions corresponding to the three branches of the Keewatin belt. The north-west corner of the area tapers off to a band which is traceable through to the south-end of Snare Lake to Mirror Bay of Pickerel Lake. The south-east corner tapers rapidly south of Vista Lake, and although exposed on the shores of Twist Lake the trough which it forms is pinched out between the latter and the north shore of Pickwick Lake where the Keewatin rocks are all hornblende schists. To the north-eastward it seems to thin out more gradually, traces of the agglomerates being observed at the north end of Windigons Lake, though not apparently in any well defined band.

Hornblende schists and altered traps of Manitou Lake.

West of the band which is formed by the north-eastward extension of these agglomerates is a band of hornblende schists and altered traps. Though there is little or none of the hard, black, glistening hornblende schist which characterises the Keewatin rocks at the base of the series when in contact with the Laurentian gneiss, this band, so well exposed on Manitou Lake, is very probably a repetition due to folding of the same rocks as those at the east end of the section, which are in contact with the Laurentian gneiss. The more schistose varieties of the rocks of this band are often quite soft and chloritic and there are not wanting local patches of small extent of fissile soft-grey schists. Many of the schists were observed to be charged with carbonate of lime or dolomite, and masses of the latter several yards in extent were observed which are probably segregations. A good deal of this dolomite occurs in the schists on the north-west side of Manitou Lake below Peep Bay, but none of it takes the form of distinct beds. The altered traps are nearly all somewhat schistose. The rocks are all in a nearly vertical attitude.

Felsite schists and agglomerates.

This band is followed to the north-west, on the west side of Manitou Lake, by a broad band which consists for the most part of alternations of grey felsites or glossy felsitic schists and felsitic agglomerates. Associated with these is a subordinate band of fissile, soft, glossy, grey schists and another of green hornblendic schists. The sequence from Paddle portage on the west side of Manitou Lake, to the north-west side of Lake Harris where the Keewatin rocks are in contact with the Lake Harris Laurentian area, is easily made out from the excellent exposures on Grant, Sairy Gamp, and Harris Lakes to be as follows, in a direction more nearly transverse to the strike than the

line of section I-J :—Agglomerate schists, ½ mile; soft, glossy, grey, fissile schists, ¼ mile; agglomerate schists, ⅛ mile; felsitic schists, ½ mile; green hornblende and chloritic schists, ¼ mile or less; agglomerate schists, 1¼ mile; felsitic schists, ¾ mile; Laurentian gneiss (or granite), indefinite extent. The measurements are, of course, approximate, but the sequence in about these proportions is undoubted; and, as the rocks are in a vertical attitude, or dipping at angles rarely less than 80°, the section appears to represent approximately the actual thickness of this part of the series, and indeed it is probably less than the original thickness by the deformation due to pressure. The rocks of the Lake Harris portion of the Keewatin trough are stratigraphically doubtless a repetition of the agglomerates of Dog-fly and Vista Lakes, since the felsites are so intimately associated with the agglomerates, and resemble them so much in composition, that they may be regarded for stratigraphical purposes as making up one geological formation. The structure of the trough is apparently that of a double fold, such as is suggested by the colored diagramatic section I-J., the basal portion of the series at the N. W. end of the section being wanting. The section thus interpreted gives a thickness for the series of probably five miles.

Further sequence of strata on section line I-J.

Thickness of Keewatin series

The line of section K-L crosses the Seine River belt of the Keewatin rocks at a peculiarily interesting locality. We meet here, for the first time, the rocks of the Coutchiching series between the Laurentian gneisses and the Keewatin rocks, forming the floor of the trough upon which the latter rest. From the south side of the Seine River, the whole of the country to the southward as far as Namakan Lake is occupied by the Coutchiching rocks. On the north side of the south-east part of Rainy Lake, these rocks dip at low angles to the northward under the Keewatin. As the Keewatin trough is approached, however, the underlying Coutchiching beds assume gradually a more vertical attitude, and close to the contact, plunge almost vertically under the basal beds of the geologically higher series. Those basal beds are on Grassy Lake, fissile, soft, green chloritic and hornblendic schists, the detrital origin of which is established by the fact that on the north side of the lake they constitute the paste of a pebble and boulder conglomerate. The structural planes of the rocks of both the Keewatin and Coutchiching series are parallel at the neighborhood of the contact and present an appearance of conformity. This appearance is, however, only what may be expected in formations that have been so squeezed together, and affords but little evidence as to the question of original conformity or unconformity. The very marked contrast in the lithological characters of the two series is indicative of an abrupt change in the conditions of formation; and the presence

Section K-L.

Coutchiching series.

Pebble conglomerate at base of Keewatin.

Indications of unconformity.

of a basal conglomerate in the upper series, in which the pebbles have very probably been derived from the underlying formation, is also indicative of a geological break, with a period of erosion which is one of the characters of an ordinary geological unconformity. There is an absence at the contact of those very black glistening hornblende schists which so commonly characterise the base of the Keewatin where it is in contact with the Laurentian gneiss. The conglomerate is a much more voluminous formation on the north side of Shoal Lake, a little to the east of the line of section, than on Grassy Lake. A similar conglomerate occurs in an analogous position on the opposite side of the same trough on the shores of Rat-root Bay, Rainy Lake.

Rocks on Bad Vermilion Lake and Little Turtle Lake.

Nearly all the bedded rocks across the belt on the line of section, so far as can be ascertained by the exposures on Bad Vermilion Lake, Little Turtle Lake and the portage between them, are more or less fissile, soft, green, chloritic and hornblendic schists, quite similar to the schists which form the paste of the pebble conglomerate on Grassy and Shoal lakes. Farther westward, altered traps are abundantly intercalated with these fissile schists on the shores of Seine Bay and Swell Bay. On the shores of Little Turtle Lake, at the narrows, where these schists are much mixed with Laurentian gneiss, they appear to have been altered to black, glistening, hard hornblende schists.

Boss of irruptive rocks.

The chief interest attached to the section is not, however, in the bedded formations of the series, but in the irruptive rocks which occupy a boss-like area in the middle of the belt, and cause it to bulge out on either side. In the middle of the belt on the S. W. side of Bad Vermilion Lake, there is exposed a distinct boss of very quartzose medium grained granite. This boss is roughly circular or heart-shaped, its greatest diameter being about three miles and a-quarter.

Very quartzose granite encircled by very basic gabbro.

It is surrounded on all sides by an encircling area or collar of very coarse-grained saussurite gabbro, in which the felspathic constitutent (anorthite) predominates greatly over the pyroxenic constituent (hypersthene?). This encircling area of gabbro is of varying width, and on the south-east side of Bad Vermilion Lake, or to the east of the granite boss, it forms a very considerable triangular area tapering to the eastward. The evidence establishing the relative distribution of the granite and gabbro is very clear, the continuous rock exposures on the shores of Bad Vermilion Lake and the scarcely less satisfactory out-crops on the river of the same name, and on its small lake-like expansions, permit the definition of the granite mass encompassed by gabbro with a more than usual degree of precision. A second much smaller area of granite occurs to the south of this collar of gabbro, between it and the green schists of Seine River. The mutual relations of these two rocks, the one of the extreme acid type and the

other of the extreme basic, and both of an eminently granular, massive, non-foliated structure, are most interesting and suggestive. They do not form an integral part of the Keewatin series, but in their present distribution seem to represent the truncation of an immense boss which protruded through the basal portion of the series. The simplest explanation that suggests itself, and that which is most in harmony with all the facts known in this field, is that this area of massive rocks represents the roots of an immense volcano, of the age of the Keewatin rocks, and that it indicates the vent through which have been extravasated a portion of the volcanic rocks which so largely enter into the composition of the Keewatin series. In this view two very distinct kinds of rock must have come from the same vent, the basic first and the acid last. The gabbro would represent the plutonic facies of the much less coarsely-grained altered traps (diabase and gabbro) which are so abundant in the lower portion of the Keewatin series. The granite would similarly represent the plutonic facies of the felsites, felsitic schists, and felsitic agglomerates (altered quartz-porphyries and their tuffs) which are so characteristic, in this region, of the upper portion of the same series. The extravasation of basic and acid rocks in this sequence is strikingly in harmony with the conceptions of the development of the Archaean crust to which all the other facts of the region point.

An Archæan volcano.

Sequence of extravasation.

Petrography of the Keewatin Series.

Altered Diabase Trap.

The most important of the rocks of the Keewatin, and those which give character to the greater part of the series, are in this region, as on the Lake of the Woods, the bedded traps or greenstones. These rocks are in all cases very much altered from the original condition in which they existed after solidification from their molten state. The influences which have been at work in bringing about this alteration are of two kinds, viz.: (1) those of paramorphic and metasomatic metamorphism, whereby the constituent minerals have their molecular particles re-arranged physically, or their atoms re-arranged chemically, so as to arrive at a state of maximum stability for present normal conditions; and (2) those of dynamic metamorphism, whereby the structure of the rock has been altered by an actual rending and sundering of its parts, associated with the development of new minerals which in part serve as a cement between the broken pieces. The first set of these metamorphic influences is found to have affected all these old traps. The second set, the result of pressure, is found to

Two processes of alteration.

have affected only part of them. Where the pressure metamorphism has been at work, we have, therefore, a combination of both sets of influences. The rending effects of pressure appear to afford the most favorable conditions for metasomatic changes, so that under such a combination of metamorphic agencies, the alteration from the original type is often so extreme that it is not possible to recognise it in the present form of the rock, and it can only be inferred by analogy. When the rock has undergone changes of a purely paramorphic or metasomatic character, scarcely, if at all, affected by pressure, it is usually not difficult, with a knowledge of fresher or younger rocks, and of the changes which their constituent minerals undergo, to arrive at a clear conception of its original form. Thus, among the altered traps of the Keewatin series it is possible to detect two closely allied types of rocks from which the present greenstones must have been derived. These are diabase and gabbro. In their fresh forms these two types are, as is well known, distinguished chiefly by their structural differences, together with an incidental foliated condition of the pyroxene of the gabbro which is not observable in the diabase. These differences are, in the nomenclature of Rosenbusch,* briefly, that in the gabbro both plagioclose and pyroxene are of synchronous generation, and consequently of allotriomorphic form, and the structure granular as in granites; while in the diabase, the plagioclase is of earlier generation than the pyroxene, and is of idiomorphic form, while the pyroxene is allotriomorphic, or at least hypidiomorphic; and the structure of the rock tends to the porphyritic. Now, when the rock has been subjected to simple paramorphic or metasomatic changes, even to an extreme degree, these structural differences are not obliterated, although the felspars may be entirely changed to saussurite, or replaced by calcite and quartz. In the one case, the characteristic idiomorphic form of the felspar still remains, and in the other the allotriomorphic. Again, although the pyroxene may be entirely re-placed by its paramorph hornblende, or even by chlorite, the relations in form of the secondary mineral to the plagioclase, depend upon the original conditions of crystallization, and are scarcely less distinct than in the case of the fresh minerals. So far as observation has gone on the bedded traps of the Keewatin series it seems to be a general rule that the foliated pyroxene of the rock of the gabbro type has been more resistant to paramorphic incroachment than has the augite of the diabase. A large number of slides have been examined, and in nearly every case where the ophitic or diabase structure was evident, there was no trace of augite remaining; while in the hornblende of rocks of granular structure, cores of diallage were not infrequently observed.

Diabase and gabbro. Distinction between.

To what extent distinctions are retained or obliterated by paramorphic or metasomatic alteration.

* Mikro. Phys. der Massig. Gestein. Stuttgart, 1886.

If we pass now to those rocks in which, in addition to paramorphic and metasomatic changes, there are evidences of crushing and stretching, where, besides the breaking and sundering of the crystals, those changes have proceeded much more actively than in less disturbed rocks, the difficulty of assigning a rock to a particular original massive type, or of asserting, with confidence, that it ever was a massive rock crystallized from a magma, becomes greater and increases proportionately to the violence of the crushing action. When the comminution of the rock has proceeded so far that the original structure is quite obliterated, the only grounds for asserting that the rock is an altered trap is that of analogy established by the study of gradations from rocks whose structure is intact. In extreme cases, however, the aspect of the rock under the microscope is undistinguishable from that of undoubted clastic rocks, such as the paste of certain pebble conglomerates and volcanic agglomerates. This paste would appear, in most cases, to have been originally made up of volcanic débris of the same material as that constituting the original diabase or gabbro rocks with which they are associated. This compacted débris or clastic rock, having been subjected to the same conditions of paramorphic, metasomatic and dynamic metamorphism as the massive rock, naturally presents much the same aspect as the massive rock whose structure has been crushed out of recognition.

Effect of dyamic metamorphism.

Difficulty of distinguishing between originally massive and originally clastic rocks when both have been much crushed.

From these considerations it will be apparent that when we have reached the limit of alteration, which still leaves us grounds for ascribing to a rock a once massive condition, we come upon a class of rocks between these and certain undoubtedly clastic rocks, of which it is impossible, at present, to determine the original condition. The altered traps which are altered only by paramorphic and metasomatic agencies, without the intervention of pressure sufficiently great to produce crushing effects, do not appear in the Keewatin series to be perceptibly schistose, but on the contrary, to have an eminently massive aspect. With the first evidence of crushing, however, as revealed by the microscope, in the sundering of minerals, etc., there is an accompanying development of a schistose structure, observable microscopically, which becomes more and more pronounced in proportion as the yielding of the rock to pressure has been great.

The green rocks of palpably clastic origin, other than agglomerates, appear to be the most fissile and schistose rocks of the series. Hence we have a gradation in schistosity from massive, practically uncrushed traps, through more and more crushed and stretched traps to the fissile condition of the chloritic schists of clastic origin; those of medium degree of schistosity, generally speaking, being those of which it is impossible to say that they were originally massive or clastic.

Degrees of schistosity.

The detailed results of the study under the microscope of the altered traps of the Keewatin series are given in more or less categorical form. The statement of observations, together with the localities, will serve as a record to which reference may be made conveniently in a more comprehensive treatment of the geology of the region. Those schistose rocks which resemble traps, but whose original characters as such, cannot, on account of their extreme alteration, be certainly determined, are considered by themselves.

Rocks on section from Bear's Passage to Seine River.

On the shores of Swell and Seine bays, the rocks of the Keewatin series lie in a sharply folded synclinal trough flanked on either side by the schists of the Coutchiching. A section from the Bear's Passage to the mouth of the Seine River shews this Keewatin trough to be made up very largely of altered traps, massive and schistose, and various kinds of green hornblende and chloritic schists.

A number of the traps crossed in such a section, as observed on the shores of Swell and Seine bays, have been examined, and the results are given first as representative of these rocks in an almost complete section across the Keewatin trough.

Gabbro one mile east of Bear's Passage.

Section No. 1604.—About one mile east of Bear's Passage, Swell Bay. Mottled green and white, massive, crystalline rock.

Under the microscope it presents the characters of a uralitic saussuritic gabbro, the structure being granular rather than ophitic. The felspar is almost entirely altered to zoisite and the pyroxenic constituent to a pale green hornblende, both fibrous and compact, the latter being frequently twinned according to the common law ($\infty P \bar{\infty}$). Leucoxene in irregular brownish-grey grains is the only other prominent mineral present.

Section No. 1606.—Half a mile north of last locality, Swell Bay. Greenish-grey massive rock of rather fine texture. It has a much smaller proportion of felspar than the last, and is made up chiefly of hornblende, in ragged, sheet-like or fibrous masses, with epidote in stout columnar, colorless crystals and in aggregates of grains. A little chlorite, leucoxene, magnetite and secondary quartz are also present.

Secondary enlargement of hornblende crystals.

The compact hornblende of this section occasionally appears in sharply defined crystals, with a fringe of fibrous hornblende of apparently the same optical orientation as the nuclear crystal, the appearance being much the same as that figured by Becke.* The sharp line between the compact hornblende and the fibrous margin of the same orientation sometimes observed recalls the secondary enlargment of hornblende as described by Van Hise.† The original augite of the rock appears to

* Eruptivgest. aus der Gneissformation des Niederösterreichischen, Waldviertels. Min. und Petrog. Mitt. von G. Tschermak, 1883, p. 159, fig. 6.

† Am. Jour. Sci. Sept., 1885.

have been changed within its own limits to compact hornblende which has become enlarged by a fibrous margin subsequently. The only indication of the original augite now remaining is the pale color of the central portions of the hornblende. The fibrous green hornblende is occasionally seen to be developed along the cleavage of the compact lighter colored mineral. The aspect of these enlarged hornblendes is shewn in Fig. 1 drawn with camera lucida from section of an altered diabase (734) from south side of Grassy Island, which is here not further described.

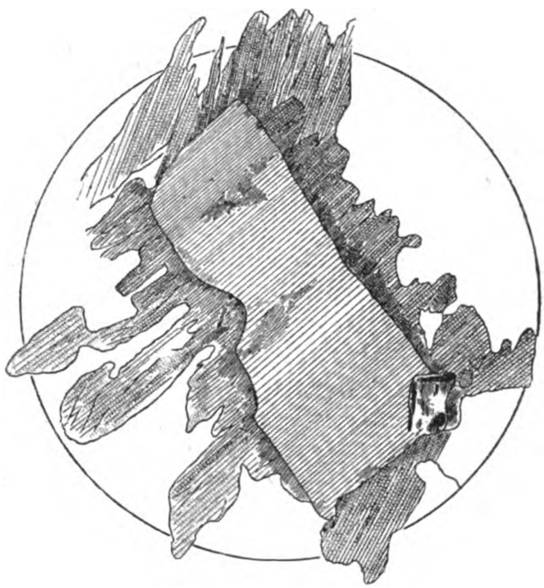


Fig. 1.—Crystal of compact hornblende with light colored central portion, secondarily enlarged by fringe of columnar or fibrous, deep colored hornblende of the same, or approximately the same, optical orientation as the central crystal. From altered diabase of south side of Grassy Island. × 18.

Section No. 1607.—One mile and three-quarters east of the Bear's Passage, Swell Bay. It is more chloritic than 1606, and contains much more magnetite. Epidote, zoisite and leucoxene are common throughout the section.

Section No. 1610.—Two miles and a-half east of the Bear's Passage. Light, mottled green, granular, uralitic, saussurite gabbro. The plagioclase is cloudy with decomposition products and is partly altered to saussurite. The twinning traces are not altogether obliterated, and twins of both the albite and baveno types are observable. A large part

Two and a-half miles E. of Bear's Passage.

of the hornblende is fibrous, though mostly compact, there being no pyroxenic mineral left unchanged. Pleochroic chlorite, in pale-green colors, colorless epidote, leucoxene with cleavage traces of the titanic iron still remaining, and magnetite are present, besides garnet in rounded colorless isotropic grains full of inclusions.

N. E. corner of Swell Bay.

Section No. 1614.—North-east corner of Swell Bay. Moderately coarse greenish-grey crystalline rock. Under the lens or low power of the microscope it exhibits a "flaser," or squeezed and pulled arrangement of the component minerals. The plagioclase is in long, lath-shaped crystals and is usually cloudy with decomposition products. The twinning structure is obliterated in some cases, but quite distinct in others. The hornblende is partially replaced by chlorite and calcite. Besides these, quartz and epidote are present in considerable quantities. Both quartz and calcite occur in mosaics of small interlocking grains, the mosaic areas having a parallel arrangement. The chlorite often appears as a base in which are imbedded grains of calcite and epidote. Leucoxene, with opaque nuclei of titanic iron is abundant. Associated with leucoxene, and apparently of the same secondary origin, are small double-wedge shaped crystals of titanite.

S. E. corner of Swell Bay.

Section No. 1618.—South-east corner of Swell Bay. Light greenish-grey, rather finely crystalline rock. Under the microscope it presents the characters of a uralitic diabase. The felspar is represented only by saussurite, of which zoisite is the most abundant constituent. The hornblende appears in section in ragged plates. Pleochroic chlorite, calcite in occasional large grains, quartz and leucoxene, with sometimes an opaque nucleus, are the less prominent minerals.

S. shore Swell Bay.

Section No. 1621.—South shore Swell Bay, near east end. Rudely schistose, green uralitic diabase. The plagioclase is in fresh crystals lath-shaped and twinned. The augite is still left in a fresh condition, and is seen in hypidiomorphic and allotriomorphic grains, occasionally shewing polysomatic structure. The felspar contains inclusions of acicular actinolite, besides a number of stout little bodies of high refractive index. The secondary minerals are: hornblende and chlorite as alteration products of the augite, which is often entirely replaced by them; quartz in mosaics, with an occasional grain of calcite; calcite in large single grains and in separate mosaics like the quartz; and leucoxene in large grains. Shreds of fibrous hornblende or actinolite derived from the augite are observed to have been developed within the substance of the fresh plagioclase, and along its line of contact with the augite.

Section No. 1622.—Half a mile west of last. Fine-grained green rock, made up of fresh plagioclase, in which both the albite and baveno twinning laws are observed, fibrous hornblende, epidote in large yellow

crystals, quartz in mosaics, large grains of leucoxene with cleavage traces, and a little calcite and iron oxide. The leucoxene is frequently faulted or crumpled by pressure, and chlorite has been developed along the cleavage lines. The felspar is also occasionally bent and broken, and the cracks filled with a cement of secondary hornblende and chlorite.

Section No. 1625.—South side of Swell Bay. A massive green schist. Under the microscope it has the structure of a porphyritic diabase, much altered. In a fine-grained ground mass of felspar, epidote and chlorite are imbedded large lath-shaped crystals of felspar which often S. shore Swell Bay.

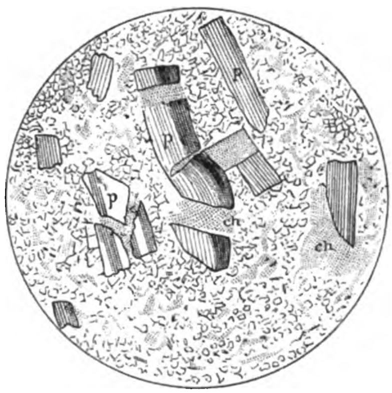


Fig. 2.—Section of altered diabase from Swell Bay, Rainy Lake, shewing bent, broken and sundered crystals of plagioclase (p), the cracks being filled with chlorite (ch). × 44.

shew pressure or rending effects very markedly, the crystals being torn apart and the cracks filled with chlorite (Fig. 2). Quartz occurs in mosaics with which are associated octahedra of secondary magnetite, some of which are surrounded by rims of hornblende. Calcite is present sometimes as a pseudomorph after the porphyritic felspar, but oftener in irregularly scattered grains. Leucoxene is abundant, often with chlorite deposited along the cleavage cracks of the original titanic iron, giving rise to a beautiful series of bars of alternating grey and bright green in ordinary light, or grey and black in polarized light between crossed nicols.

Section No. 57.—Four miles east of Little Rocky Narrows, north shore, Seine Bay. A uralitic diabase, composed of an aggregate of lath-shaped crystals of plagioclase and green uralitic hornblende, the latter greatly predominating. The felspar is largely decomposed and is replaced in part by epidote. Numerous isolated grains of clear quartz are scattered through the section. Seine Bay.

Section No. 59.—Six miles and a half east of Little Rocky Narrows, north shore of Seine Bay. A porphyritic uralitic diabase in which the ground mass is an aggregate of fresh lath-shaped plagioclase and hornblende. In this are imbedded large crystals of plagioclase, which are partially replaced by epidote and zoisite. Needles of apatite occur in the felspar. Numerous anastomosing veins of epidote traverse the section, throughout which are also scattered in sparing quantities calcite and chlorite.

Rock at mouth of Seine River.

Section No. 2101.—Seine River near the mouth. A medium textured massive green rock. Original character scarcely determinable but presents the aspect of a much altered porphyritic trap. It is made up of a rather non-descript aggregate of plagioclase, chlorite, epidote, quartz in lenses with granular margins, leucoxene with opaque nuclei and calcite. In this base are imbedded large cloudy crystals of felspar.

Porphyritic diabase at base of Keewatin series, Bleak Bay.

Section No. 60.—Base of Keewatin series, Bleak Bay, north side. A massive green rock of fine-grained texture with occasional porphyritic crystals of plagioclase. Under the microscope it presents the aspect of an altered diabase. The plagioclase is in large, rather stout, crystals, sometimes in idiomorphic development, but more frequently hypidiomorphic. The augite occurs in hypidiomorphic crystals almost entirely altered to hornblende and chlorite. Secondary hornblende chlorite and epidote have been developed very extensively along cleavages and cracks of the fresh plagioclase. The accessory minerals are apatite and magnetite, both well crystallized and the latter observed, in some cases, enclosing the former.

The belt of the Keewatin rocks, which may be seen in section between the Bear's Passage and the Seine River, continues westward across Rainy Lake. A few more characteristic specimens of the altered traps from this portion of the belt have been examined.

Berry Island.

Section No. 1537.—North side of Berry Island, Rainy Lake. A medium textured, green, altered diabase with roughly schistose structure, made up of cloudy, lath-shaped plagioclase and irregular but generally elongated crystals of hornblende of a rather pale-green color, quartz, with inclusions of small colorless microlites and epidote are plentiful, the latter most frequently occurring in the hornblende.

Section No. 1538.—North side of Berry Island, half a mile east of last locality. A fine-textured massive green uralitic diabase. The diabase structure is well preserved. Plagioclase in cloudy, slender, well defined, lath-shaped crystals is imbedded in broad plates of hornblende which is partly altered to chlorite. Considerable calcite, secondary quartz, in mosaics, and some leucoxene are present.

Section No. 1539.—Eastern extremity of Berry Island. Finely mottled green and white uralitic diabase, in which the characteristic

diabase structure is less perfectly preserved than in the last. The rock is made up of cloudy plagioclase in rather stout lath-shaped crystals; hornblende, in allotriomorphic development; leucoxene, with cleavage traces of original titanic iron; and a considerable amount of quartz.

Section No. 1549.—South side of Berry Island. A medium-grained dark-green altered trap which in structure partakes partly of the character of a diabase and partly that of a gabbro. The felspar appears in lath-shaped crystals, and in broad irregular tabular masses largely replaced by calcite, quartz, epidote and kaolin. The hornblende also occurs in elongated prisms and in broad masses of irregular shape, giving the section, on the whole, a granular aspect.

Section No. 709.—South side of Rat-root Bay, Rainy Lake. A greenish-grey crystalline rock of medium texture with a rude ill-defined schistose structure. Under the microscope, the structure is seen to have been much affected by pressure and stretching. The horn- Rock on south shore Rat-root Bay.

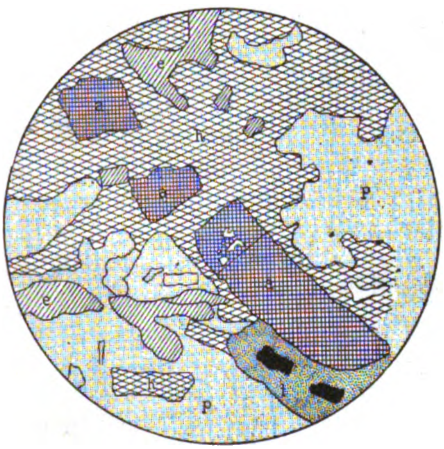


Fig. 3.—Section of altered diabase from Rat-root Bay, Rainy Lake, shewing stretching effects as evidenced by sundered crystal of apatite. × 120.
a, a, a. Apatite—same individual.
h. Secondary hornblende—various individuals.
p. Plagioclase.
l. Leucoxene.
e. Epidote.

blende mostly presents a very ragged aspect and is torn asunder with secondary hornblende developed in the cracks. In this torn and parted condition it seems to have been very liable to alter to biotite which accompanies it in considerable quantities. The plagioclase is occasionally seen in long lath-shaped crystals, but for the most part, the diabase

Effects of pressure.

structure of the rock has been obliterated by the crushing and stretching to which it has been subjected. The felspar is seen to have been broken, and the smaller fragments, together with decomposition products, such as calcite, epidote, quartz and albite, form a base in which

Fig. 4.—Stretched and sundered crystal of hornblende, with shreds of secondarily developed hornblende, some leucoxene and grains of titanic iron, in altered diabase from Rat-root Bay, Rainy Lake. × 44.

the larger felspars and the more resistant hornblendes appear to be imbedded. Apatite occurs as an original constituent, and shews very well the sundering process which the rock has undergone. Magnetite is present as an associate of the hornblende, and quartz in mosaics and titanic iron with leucoxene are abundant.

Another folded trough of the Keewatin rocks, flanked also on either side by the schists of the Coutchiching series, is well exposed in section on the shores of Rocky Islet Bay. The results of the examination of the altered traps of this belt is now given.

North of Back Point.

Section No. 1493.—Island three-eighths of a mile north of Back Point. A coarse-grained, mottled, dark-green and yellowish-white, schistose altered trap. Under the microscope it is made up of large individuals of plagioclase in hypidiomorphic development, beautifully striated, and compact green hornblende, interstitial and enveloping the felspar.

Section No. 1494. Half a mile north of Back Point. Dark-green, fine-grained, altered diabase made up in thin sections of plagioclase in unusually long lath-shaped crystals, and hornblende in broad plates. The plagioclase is often broken; and fragments of plagioclase, original or secondary, quartz, epidote and calcite, make up a fine-grained secondary base.

Rock on island of Rocky Islet Bay.

Section No. 1499. Small island on west side of Rocky Islet Bay. A coarse-grained rock of granitic aspect, composed of lilac-colored felspar, yellow in patches from the presence of epidote, and a green pyroxenic mineral, largely changed to micaceous chlorite. Under the microscope the plagioclase appears in broad plates, sometimes quite fresh, but usually decomposed and altered to epidote and kaolin. The pyroxene is rhombic and slightly pleochroic. When it has escaped alteration to

chlorite, it must be regarded as bronzite or enstatite. Magnetite is present in sparing quantity.

Section No. 1500. West side of Rocky Islet Bay. A medium-grained, mottled, greenish-grey rock with foliated structure. Under the microscope it has the character of an altered gabbro, being made up of a granular aggregate of non-pleochroic foliated pyroxene, with an extinction of over 30° (diallage) and plagioclase. The fresh diallage is not abundant, and it is always partially altered to hornblende and chlorite, while there is an abundance of hornblende which, although it shews no cores of diallage, is doubtless paramorphic after that mineral. The felspar is very largely altered to zoisite, which appears in large patches with rounded areas of unchanged felspar included in it. Epidote is also an alteration product of the felspar, but it is very much less abundant than the zoisite. **West side of Rocky Islet Bay.**

The following three specimens were taken from the same mass of bedded trap at the north end of Rocky Islet Bay. No. 1503A is from the middle of the bed, 1503C from its contact with adjoining schists, and 1503B from a point intermediate between these. **Bedded trap north end of Rocky Islet Bay**

Section No. 1503A. A mottled green and white diorite-like rock of medium texture and granular structure. In this section it appears as an altered gabbro made up of a granular aggregate of diallage, with paramorphic hornblende and plagioclase, with a considerable amount of epidote. The diallage is in large plates of grey color, showing very distinctly the usual parting parallel to $\infty P \bar{\infty}$ upon which the extinction angle is 25° and upward. It is altered to green compact hornblende on its borders, and irregularly shaped plates occur, made up entirely of the hornblende which, however, is light-green to almost colorless in the centre, and deep green towards the periphery. In both diallage and hornblende, minute inclusions occur, arranged parallel to the parting of the one and the cleavage of the other. The plagioclase is cloudy with kaolin, epidote and zoisite. A little biotite, is also observable in the section. **Middle of bed.**

Section No. 1503B. Finer grained and darker colored than A. Under the microscope it resembles A, but there is no diallage left, that mineral having been entirely changed to hornblende, which is frequently dusty, with grains of magnetite, usually heaped together in the centre of the crystal, but occasionally in distinct octohedra. Some of the plagioclase is almost opaque with decomposition products, among which epidote is prominent; while other crystals are clear and glassy, and abound in inclusions of straight colorless microlites. **Intermediate part of bed.**

Section No. 1503C. A little finer grained than B, but more distinctly crystalline and glistening and of a darker color. The rock is a granular aggregate of hornblende and plagioclase, together with small quan- **Edge of bed.**

tities of quartz, epidote and magnetite. The hornblende, in some basal sections, is seen to have the outline of a perfect prism.

West side Rice Bay.

Section 1519B. Rice Bay Narrows, west side. Medium textured, mottled white and black altered gabbro, composed of a granular aggregate of plagioclase, hornblende and biotite, with some non-striated felspar. The plagioclase is for the most part fresh, being only occasionally cloudy with decomposition products. The hornblende is not so abundant as the plagioclase, and the biotite which accompanies it is apparently secondarily derived from it. In the case of some of the hornblende crystals, undoubted pyroxene can be detected, with brilliant polarization colors and high extinction angle. A few crystals of apatite occur in the hornblende.

Rock at north end of Bear's Passage, Redgut Bay.

Section No. 1561. Island at the north end of the Bear's Passage, Rainy Lake. A medium textured mottled black and white altered trap composed of a granular aggregate of plagioclase hornblende and titanic iron with rims of leucoxene. The felspar is rather decomposed, giving rise to quartz and epidote. It occasionally occurs in lath-shaped crystals, but for the most part, both the felspar and hornblende are allotriomorphic and the structure granular, inclining to the gabbro rather than to the diabase type. This trap rock holds included in it angular fragments of an older rock of finer texture and greener color. A section No. 1561A of one of these inclusions shews it to be made up of a felt work of hornblende, with considerable quartz, and a little plagioclase chlorite, epidote and leucoxene with opaque nuclei. The rock affords little indication of its original structure or mineral composition.

West side of Redgut Bay.

Section 1601A. West side of Redgut Bay, north of the Bear's Passage. A medium textured, black-green, massive, crystalline rock, made up of a granular aggregate of compact green hornblende in large irregular plates, with a little very cloudy interstitial felspar, some water-clear quartz, and fresh non-striated felspar. A little epidote is associated with the cloudy felspar.

Section No. 1601B. Same locality as last, and apparently only a different facies of the same rock, being greyer in color, and more quartzose and epidotic. The hornblende is largely altered to epidote, and the quartz occurs in mosaics of large grains. Grey leucoxene with opaque nuclei is the only other mineral.

Squall Point, Rainy Lake.

Section No. 763. Squall Point, Rainy Lake. A coarse textured uralitic diabase included in gneiss. Under the microscope, the hornblende is in large compact masses, with very frequently a pale green, almost colorless central portion, indicating the earlier form of the mineral as augite, and indeed in some cases traces of the augite itself appear still to remain. Epidote and magnetite are associated with the

hornblende. Plagioclase is in rather stout lath-shaped crystals, somewhat cloudy, but with twinning structure well defined; apatite and quartz are present in sparing quantities.

The following six specimens were taken from the Keewatin belt, as exposed on the shores of Manitou Lake:

Manitou Lake, opposite Snare Bay.

Section No. 1139. West side of Manitou Lake, opposite Snare Bay. A mottled green and white, altered gabbro of medium texture. Seen under the microscope, to be made up of a granular aggregate of diallage and felspar, the latter being almost completely changed to a dense, cloudy, grey mass which, between crossed nicols appears as zoisite. The diallage is partially altered to hornblende. The only other mineral to be noted is leucoxene. Pressure effects are observable only to a very slight extent.

E. side Manitou Lake.

Section No. 1088.—Manitou Lake, east side, about a mile and one-half north-east of Snare Portage. A much altered diabase. The augite is represented now only by chlorite, having first probably passed through the uralitic stage. The plagioclase is nearly all replaced by calcite and chlorite, its long lath-shaped form being, in most cases, all that is left to determine the character of the original mineral. There is a good deal of quartz present, some of which holds needles of apatite as inclusions. Leucoxene occurs in large patches, with black opaque grains scattered through it, and shows pressure effects in being torn asunder. A little pyrite in cubes is also present.

Peep Bay, Manitou Lake.

Section No. 1105.—West side of Peep Bay, Manitou Lake. A rudely schistose green rock, apparently a very much crushed and altered diabase. It is made up of fragments of plagioclase and quartz, imbedded in a base which is largely made up of chlorite and calcite, the former of which shews a tendency to a parallel linear arrangement which determines the schistosity. Both chlorite and calcite fill the interstices between the dislocated felspars, and many of the latter are wholly or partially replaced by secondary quartz, calcite and chlorite. Although the original structure of the rock is obliterated, it appears altogether probable, from the frequent idiomorphic lath-shaped character of the plagioclase or its pseudomorph, that the rock was originally a diabase.

Section No. 1106. West side of Peep Bay, Manitou Lake, half a mile north of last. A light greenish-grey, somewhat mottled, finely crystalline altered diabase. Under the microscope the rock shews abundant evidence of crushing and stretching. The stout, lath-shaped crystals of plagioclase, which are quite fresh, are frequently broken and parted, the cracks being filled in with chlorite, calcite, epidote and quartz. Titanic iron, with associated leucoxene, is abundant, and is, like the felspar, frequently sundered. Irregular masses of chlorite appear to be

all that is left to represent the augite. The lath-shaped felspars are surrounded by the chlorite as they are by augite in fresh diabase. In between these masses of chlorite, crystals of felspar and grains of titanic iron, there is a base made up of a mixture of grains of chlorite, epidote, quartz, calcite and magnetite.

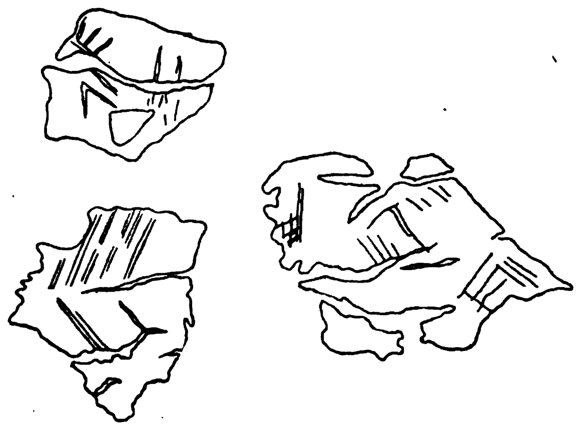


Fig. 5.—Stretched leucoxene in altered diabase from Peep Bay, Manitou Lake. × 44.

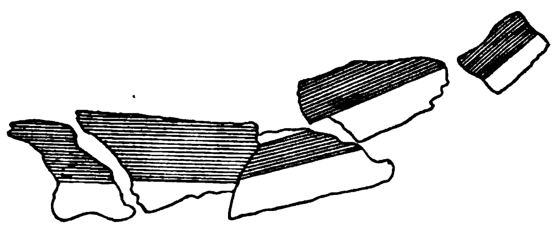


Fig. 6.—Shattered crystal of plagioclase in altered diabase from Peep Bay, Manitou Lake. × 44.

E. side Manitou Lake, opposite Peep Bay.

Section No. 1123.—Manitou Lake, east side, opposite Peep Bay. Greenish-grey, roughly schistose altered trap with an unctuous feel on cleavage surfaces. Under the microscope it presents the appearance of a very much crushed rock. The most prominent constituent is a comparatively fresh plagioclase, which is nearly always broken and appears, in some instances, to have been pulverized to a granular mass which probably, in a partially recrystallized form, mingles with chlorite and calcite, to form a secondary ground mass analogous to the "*Mörtel structur*" of Törnebohm. The augite is represented only by chlorite.

Apatite and titanic iron with leucoxene are present, but not abundant. The structure of the rock is almost obliterated, but it is probably only a cataclastic diabase. A section (1126) of a similar rock from near the same locality as last, which differs from it chiefly in the presence of biotite, is illustrated in Fig. 7, where the tearing apart of the felspars is well shewn.

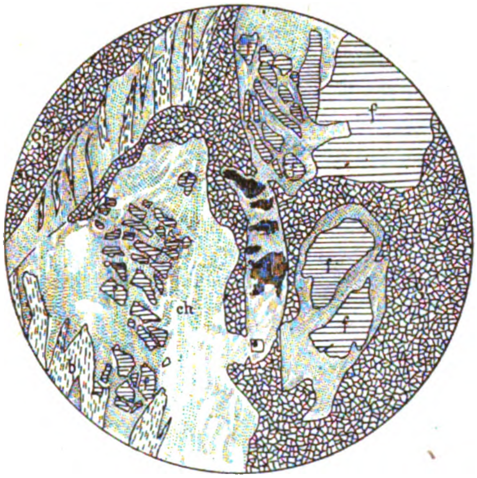


Fig. 7.—Section of much altered rock from east side of Manitou Lake, shewing sundering of felspar crystals. × 44.

f. Felspar, mostly torn into several pieces.
ch. Chlorite.
b. Biotite.
l. Leucoxene.
gr. Ground-mass, crushed felspar, quartz, calcite, chlorite and muscovite.

Section No. 1117.—West side of Manitou Lake, two miles north-east of Paddle Portage. A fine textured, green, altered diabase, which shews under the microscope the typical diabase structure. Small lath-shaped crystals of quite fresh plagioclase, occasionally bent, but never broken, are surrounded by hornblende which is partially altered to chlorite. Associated with chlorite are epidote, calcite, and pyrite in cubes. **W. side Manitou Lake.**

The following five specimens are taken from exposures of the same belt as exposed much farther to the east on the shores of Crow Lake, Pipestone Lake and Kishkutena Lake.

Section No. 25.—Extremity of point on Crow Lake, half way between Crow and Wade portages. Uralitic diabase porphyrite (?) shewing a fine-grained ground mass of calcite, epidote, chlorite, hornblende, quartz and leucoxene, in which are imbedded large, rather

S. W. side Crow Lake.

stout, lath-shaped crystals of plagioclase which are often partially replaced by calcite. These felspars are often torn asunder, and the intervening cracks filled with chlorite. The felspars are also frequently surrounded by a deep fringe of chlorite, which is bright green and slightly pleochroic in ordinary light, and deep olive green to opaque between crossed nicols. The fibres or scales of the chlorite are observed to stand perpendicular to the contours of the felspar. Hornblende in large porphyritic crystals, frequently twinned, is as plentiful as the felspar.

S. shore Crow Lake.

Section No. 108.—South shore of Crow Lake opposite Patch Island. A coarse greenish-grey rock, with yellowish-white weathering, appears under the microscope as a uralitic saussurite gabbro, made up of a granular aggregate of hornblende and saussurite, the former predominating and frequently twinned. There is present also considerable grey leucoxene, with sometimes an opaque nucleus of titanic iron, secondary quartz enclosing needles of actinolite and chlorite in veinules. The saussurite is chiefly made up of bright blue polarizing zoisite.

Near Shanty Point, Crow Lake.

Section No. 145.—Bay west of Shanty Point, Crow Lake. A medium textured altered diabase of mottled aspect, due to intermixture of greenish-grey chloritic mineral and greenish-yellow felspar. Under the microscope, the plagioclase is in well defined lath-shaped crystals, very largely changed to saussurite, which renders it cloudy almost to opacity. Interstitial hornblende altered, for the most part, to chlorite, and grains of leucoxene make up the rest of the section.

N. W. side Pipestone Lake.

Section No. 306.—Island off the north-west side of Pipestone Lake. Mottled green and white uralitic saussurite diabase. Under the microscope the lath-shaped plagioclase appears as a cloudy aggregate, which the analyser resolves into albite, zoisite, epidote, muscovite and calcite, constituting the decomposition aggregate known as saussurite. The original pyroxenic constituent is represented now by elongated, often twinned, crystals of hornblende. A little quartz is present, also leucoxene with opaque nuclei.

S. side Kishkutena Lake.

Section No. 1892.—Kishkutena Lake, south side. An altered trap of eminently porphyritic facies. Macroscopically, it appears as a fine-grained ground mass, of green color, in which are imbedded large white sharply defined crystals of felspar, often as much as an inch in diameter. These crystals are sometimes observed to enclose portions of the ground mass. Under the microscope, the ground mass is made up of an aggregate of small grains of felspar, quartz and hornblende. The hornblende is in long prisms and short, more or less granulitic or rounded grains, with which are associated a little calcite. The porphyritic felspars are almost entirely replaced by zoisite, calcite, albite and muscovite, the first named mineral predominating, making up the

saussurite aggregate. A veinule of mosaic quartz and albite traverses the section. The section does not satisfactorily reveal its original character, but there is no doubt of its having been the porphyritic facies of a basic massive rock.

Hornblende Schists.

In the rocks here considered there is no conclusive evidence as to their original character, whether they were massive or clastic. There is much presumptive evidence in favor of the view that they are partly altered massive rocks and partly altered volcanic ash beds (pyroclastic) but little or none that they are the alteration products of clays or other forms of detrital matter. The changes which these rocks have undergone have been so profound that only occasionally can a trace of their original character be discerned; and we have a new rock in which the constituent minerals have crystallized in situ, and have, since their crystallization, been practically undisturbed by pressure, except to this extent that the pressure was probably constant while secondary crystallization was in process. If dynamical influences were potent in the destruction of the original structure, as we must admit from the conditions of their occurrence, and their association with rocks that afford good evidence of crushing, chemical or metasomatic changes, have since been sufficiently active to have obliterated all or nearly all trace of crushing, and have replaced the crushed aggregate by an assemblage of minerals each of which has been formed under conditions implied by the contemporaneous crystallization of the others.

Evidence of origin of hornblende schists.

The rocks classed as hornblende schists exhibit within certain narrow limits a considerable diversity in their microscopic aspect. They are, however, for the most part, aggregates of hornblende and quartz, the common accessory minerals being epidote, zoisite and magnetite.

Diversity in microscopic aspect.

In one variety a colorless base of quartz grains, which in section appear as a mosaic, forms a matrix in which are imbedded the hornblende individuals as the predominant constituent. Two fairly distinct phases of structure are observable in this variety, which are manifested particularly in the form and arrangement of the hornblende. In the first of these, the hornblende assumes sheaf-like forms, compact towards the middle, but frayed out into a radiating tuft of a more or less fibrous character at one or both ends of the somewhat elongated individuals, the elongation being, of course, in the direction of the *c* axis. These sheaf-like masses are thrown indiscriminately together so as to form a more or less intricate felt-work. In the second phase of structure the hornblende is uniformly compact, and assumes the form of

Two phases of first variety of hornblende schists.

single prisms which are either short and oblong in shape, or have the shape of long slender needles or rods. These stout oblong prisms are in parallel alignment. The more slender rods or needles are less strictly so, and may cross each other at small angles and produce a felted aspect in section.

The structural features thus indicated are doubtless a function, both of the original character of the rock and of the conditions under which secondary crystallization has taken place, and although those conditions are not yet understood, it is altogether probable that a careful study of these schists will lead to as satisfactory a conception of the relations between structure and conditions of crystallization as has been established in the case of the massive rocks which have crystallized from magmas.

Two phases of second variety of hornblende schists.

2. In the other variety of these schists, plagioclase is a prominent constituent, and the rock approaches a diorite in composition, and in some cases even in structure. Two general phases of structure may also here be distinguished, viz.: that in which the disposition of the minerals is similar to that of the second phase of the first variety; and that in which the structure is more granular or dioritic.

Geological position of these schists.

The interesting feature of these rocks, when their petrographical characters are considered in connection with their field occurrence, is that they seem to be confined in the district under consideration mostly to the base of the Keewatin series, and then only when that base is in contact with the gneisses of the Laurentian, which shew abundant evidence of having existed beneath them in the state of a liquid or viscid magma, a condition of things which would amply account for their extreme alteration, especially if we consider the magma, which consolidated as the Laurentian gneiss, to have been one of hydrothermal and not necessarily of dry fusion.

Hornblende schist at contact with Laurentian gneiss.

Crow Portage.

At the contact of the Keewatin and Laurentian, at the south end of Crow Portage, the base of the former is represented by a compact, black glistening schist of freshly crystalline aspect. To the naked eye it appears to be made up of fine black needles of hornblende, all arranged approximately parallel, with an interstitial micro-crystalline greenish-grey material. Under the microscope (48A) the hornblende appears in elongated shreds and patches of bright green color. These hornblende crystals shew a distinct, though rough alignment or parallelism. The interstices between them are occupied by quartz and felspar (?) with some epidote and zoisite. The quartz is dusty with inclusions of colorless needles, liquid inclusions with and without bubbles, and gas inclusions. The epidote is rather abundant, and occurs in large, pale greenish-yellow masses, and in small oval grains which frequently have a nucleus of iron oxide.

Some of the rocks higher up in the series, but associated with schists such as that just described, are very similar to those at the contact, but are more felspathic, less evenly schistose, and of a more massive aspect. A specimen taken from Turtle Portage may be described as a type of these rocks. It is a dark-green to black rock, with a small amount of greyish-white mineral peppered through it, which comes out distinctly on the weathered surface, shewing a streaked or linear disposition. Under the microscope, the rock appears as a granular aggregate of hornblende and plagioclase, and may perhaps be designated as a diorite. It is not apparently, however, one of those rocks which are often called diorite, but which are clearly altered forms of diabase. There is no trace of diabase structure nor any evidence that the hornblende is a paramorph of any variety of pyroxene. Both plagioclase and hornblende are fresh. A little epidote and magnetite are scattered through the section. **Turtle Portage.**

On the north-west side of the lower end of Pipe-stone Lake, the rock is a dark green hornblende schist. In thin section (318) it is seen to be made up of an intimate felt work of tufts of hornblende, with a little chlorite and epidote, and considerable quartz in interlocking grains. Leucoxene is also present in long slender lenses arranged in parallel position, thus giving a decided banded appearance to the section. **Lower end of PipestoneLake.**

A somewhat similar rock occurs on the south-east side of this same lake. It is made up as seen in thin section (352) of a felt work of partially fibrous hornblende altered in places to chlorite. Considerable epidote is associated with the hornblende and magnetite in fine grains, generally disseminated. The colorless interstitial base of the rock is made of mosaic quartz.

A couple of miles along the same shore to the north-eastward in the same line of strike, the rock is a more massive, coarsely crystalline schist (355) in which the predominating mineral, hornblende, is present in the form of an intricate felt work of large hornblende individuals, and finer fibrous shreds, through which is distributed zoisite in short columnar crystals. Fresh plagioclase, probably albite, is present, as well as quartz and some leucoxene. The hornblende is in places partially altered to chlorite.

On the south-side of First-quill Lake, Kishkutena route, the hornblende schists are medium, grained, green, rather massive rocks. A specimen (1856) appears, under the microscope, to be made up of sheaf-like or double tufted masses of more or less fibrous hornblende, with a large amount of epidote and zoisite. Between these there is a fine ground-mass of felspathic material which polarizes in dull, bluish colors as an aggregate and partly shews an undulatory extinction. There are no sharply defined boundaries between the different grains. **First-quill Lake**

This ground mass shews a parallel or schistose arrangement, is in places decomposed to muscovite and epidote.

Lake Despair. A specimen of the hornblende schists which occur on Lake Despair, taken from the south-west corner of South Bay of that lake, is a fine-grained dark-green to black, hard schist seen to be made up in thin section (1743) of green hornblende, in small oblong grains, all in parallel position, with quartz in rounded oblong grains, epidote and probably some felspar. Quartz also occurs in nests or mosaics of large grains.

Cedar Narrows of Pickerel Lake. At the south end of Cedar Narrows of Pickerel Lake on the Manitou Route, the rock at the base of the Keewatin series is a compact black or dark-green, hard, slaty hornblende schist. A specimen from near the contact appears in thin section (988) to be made up chiefly of light-colored green hornblende in compact plates of irregular shape, but generally elongated parallel to the prism, and zoisite in colorless compact masses having the same orientation over wide fields, polarizing in soft blue colors and showing parallel extinction and biaxial interference figure. A few sphenes are present in well formed crystals of the usual double-wedge shape, such as are common in the syenitic gneiss of the Laurentian immediately to the south of the narrows. Epidote and chlorite appear as decomposition products of the hornblende.

West side Pickerel Lake. A specimen from the band of hornblende schists which crops out on the west side of Pickerel Lake, north of the Narrows, is a dark-green, medium-grained, rudely schistose rock (1003) made up of a felt work of compact sheaf-like hornblende imbedded in a colorless base of quartz grains in mosaic arrangement with a little epidote and leucoxene as the only other constituents.

Lake along the Hill. On the south side of the Lake along the Hill, near its middle, the rock is a compact black-green finely crystalline hornblende schist which appears under the microscope (1208) as a close felt work of more or less sheaf-like hornblende imbedded in clear quartz, in mosaic grains. The only other constituent is titanic iron in aggregates of grains each surrounded by its margin of leucoxene. The quartz manifests a peculiar state of optical tension which causes different portions of the same grain to have slightly different orientations, so that the extinction is neither uniform nor undulatory, but jumps across the section from area to area between which there are no observable lines of demarkation.

Three Island Lake. A specimen from the south-east corner of Three Island Lake, Little Canoe River route, is a fine-grained, green, hornblende schist, which is seen under the microscope (1230) to be made up of a fine felt work of shreds of hornblende imbedded in a colorless base which consists

chiefly of quartz, with some epidote, zoisite and leucoxene scattered through it. The hornblende, though matted together, shews a rough tendency to parallel arrangement.

At the mouth of the Big Turtle River, the hornblende schists of the Keewatin series are much penetrated by, and included in, the underlying Laurentian gneiss. A specimen of the schist thus intersected by the gneiss appears on cleavage faces as a black glistening rock of medium texture. On transverse fracture it appears peppered with grey-white felspar in minute specks. Under the microscope (A) it resembles the specimen from Turtle Portage, and appears as a dioritic or granular aggregate of deep colored green hornblende and fresh plagioclase, with a very little quartz, the hornblende greatly predominating. A little epidote is also present, together with some cloudy or finely granular matter shewing aggregate polarization as of a fine micro-crystalline admixture of muscovite and calcite. **Big Turtle River. Hornblende schists penetrated by Laurentian gneiss.**

The rock at the entrance to Rocky Islet Bay on the west side (1492) is a compact dark-green finely-crystalline schist made up of hornblende, quartz, and plagioclase. The hornblende is in compact, oblong grains with rounded corners all arranged in nearly parallel position. The quartz and fresh plagioclase are less abundant and are interstitial, also shewing a tendency to an arrangement in long parallel areas alternating with the hornblende. **Rocky Islet Bay entrance.**

On the north shore of Rocky Islet Bay the rock is a dark-green, fine-grained, glistening hornblende schist. Under the microscope (1502) the hornblende occurs in broad, irregularly shaped plates generally closely interlocking, but often with considerable quantities of epidote, zoisite and fresh plagioclase between the hornblende grains. A granular, nearly opaque, brownish aggregate of kaolin-like material is also present. The rock, to the naked eye, is seen to be banded with yellow areas, and a section through one of these shews it to be made up almost entirely of epidote in regular shaped oblong grains, together with a little zoisite and some hornblende, all the minerals having a more or less distinct parallel arrangement of their longer axes. **North shore Rocky Islet Bay**

Another specimen from the north end of the same bay (1503 D) is a fine-grained, greenish-grey, glistening schist made up of a mosaic of hornblende, non-striated felspar and quartz. All three minerals occur in grains of oblong shape being usually two or three times longer than broad. The hornblende grains are larger than those of the quartz or felspar, both of which are about the same size and difficult to distinguish without reference to their action on converged polarized light.

A specimen from the south side of Grassy Island, Rainy Lake, is a dark-green fissile or slaty hornblende schist, shewing in thin section (735) a felted arrangement of sheaves of hornblende of a **Grassy Island.**

more or less fibrous character, lying in a colorless matrix of quartz and calcite, throughout which are also scattered a little epidote, magnetite and chlorite.

Otukamamoan Lake.

The hornblende schists which form the middle of the three tongues into which the Keewatin belt splits up on Otukamamoan Lake are fine-grained and of an eminently crystalline, glistening, black aspect. A specimen from the west side of the lake appears, to the naked eye, to be made up of needles or prisms of black glistening hornblende, closely compacted and in parallel position, peppered with a greyish-white subordinate constituent. Under the microscope (1526) it is seen to be made up of hornblende, felspar and quartz, the first predominating in compact, deep colored, strongly pleochroic green prisms from two to four or five times longer than broad. This compact prismatic character of the crystals is very constant. The ends are sometimes sharp or jagged but more often somewhat rounded or square. These prisms are so closely packed sometimes that there is but little interstitial space between them, but for the most part there are irregular spaces which are occupied by fresh felspar and quartz, which have their contours determined by the shape of the interstices. None of the felspar was observed to be striated, and it is usually quite fresh. In both felspar and quartz there are numerous inclusions.

Memekwisi Lake.

A band of hornblende schists is exposed on Memekwisi Lake; these shew in hand specimens a black glistening surface on cleavage faces, while on transverse fracture it appears as an alternation of very thin laminæ of black glistening hornblende and greyish-white felspar and quartz. Under the microscope the hornblende appears in deep colored green patches or shreds of irregular shape, which are, however, usually elongated in the direction of the prismatic cleavage and arranged rudely parallel. The hornblende is in some portions of the section closely packed together, while in others it forms a more open felting, the interstices being occupied by plagioclase and quartz in mosaic, the former being quite fresh. The section appears to have been cut at only a small angle to the plane of foliation so that the lamination, which is so apparent in tranverse fracture, is not a marked feature of the thin section. Shreds of hornblende, together with numerous other inclusions, occasionally arranged in lines, occur in the felspar and quartz.

Longue Sault Rapid, Rainy River.

On Rainy River, at the head of the Longue Sault Rapid, the Keewatin series is represented by a dark-green, very fine textured, compact hornblende schist, somewhat glossy on cleavage faces. Under the microscope (1609) the base of the rock is seen to be made up of a feltwork of distinct, well defined needles of light green hornblende only slightly pleochroic. These needles shew a decided tendency to parallel arrangement, and the felted aspect is due to their crossing each other

at small angles, although occasionally needles may be seen transverse to the rest. The interstices between these needles are occupied by bluish felspar and a little quartz. Where the interstices are small, the grains of felspar have their shape moulded against the long needles of hornblende, but where they are more open, as is often the case, the felspar grains form mosaics, the constituent grains having a decided granulitic or rounded appearance. Grains of magnetite are commonly scattered through the section. In this base are imbedded large grains of plagioclase, both in lath-shaped crystals and in shorter tabular crystals. These are, for the most part, fresh, being only occasionally cloudy, and shew twinning lamellæ. Some of them have retained their crystallographic outline, but most of them shew a rending or granulation due to pressure and shearing; and, in some cases, the crystal has been apparently reduced to the cataclastic state (*mörtel structur* of Törnebohm). Some of these crystals of plagioclase have a broad border in which hornblende needles similar to those of the base have been developed along the cleavage partings of the felspar. The needles are abundant but are smaller and shorter than those of the base, which are often of great length. In other crystals, the development of hornblende needles is not confined to a peripheral border, but has taken place throughout the crystal, the needles always lying in the cleavage partings. The rock is doubtless an altered diabase-porphyrite in which the porphyritic plagioclase has suffered less alteration than the base. It is an interesting case where a rock having the characters of a hornblende schist still retains features which indicate clearly its derivation from a massive igneous rock. The base of the rock does not differ essentially from the sections of many of the hornblende schists above described, and the analogy is suggestive of the derivation of some of the latter from ordinary diabases free from large porphyritic crystals.

On the Pine River there are two exposures of the hornblende schists of the Keewatin. That at the first rapid is a very fine-grained, compact, hard, dark-green hornblende schist. In thin section (1617) it resembles the base of (1609). It is, however, finer-grained, and the needles more intricately felted. They show also a less regular shape. These microscopic characters seem to correspond with the fact that the rock is much less schistose than the rock at the Longue Sault. The interstitial base or matrix in which the hornblende is imbedded, is mostly bluish felspar, with probably some quartz, but too small to determine optically. Scattered through this base are attenuated linear areas lying in all directions, which are occupied chiefly by mosaics of felspar with some epidote and quartz (?). Some of these appear to be the granulated remains of lath-shaped plagioclase crystals, while others Pine River.

have rather the appearance of small cracks secondarily filled. Magnetite is sparsely distributed over the field.

The same description is applicable to the rock (1618) of the second rapids of the Pine River, except that the hornblende needles are larger and the texture, in consequence, appears coarser; and that remains of porphyritic felspar crystals are, perhaps, more distinct.

Soft Fissile Green Schists.

Clastic origin.

These are schists closely resembling the paste of some of the conglomerates. They are usually distinctly bedded. Their clastic origin can scarcely be doubted, though, as in the paste of some of the conglomerates, their association with bedded traps and their mineralogical analogy with the altered phases of those traps, renders it extremely probable they were never ordinary clays, but were originally fine-grained, volcanic ash beds, the constituent minerals of which have suffered alteration and decomposition along the same lines as those observable in the traps. They are metamorphic rocks probably only in the sense that they exemplify in bedded volcanic ashes of a certain character, those paramorphic, metasomatic and dynamic changes which are now so well known in the corresponding massive rocks.

It is often difficult to draw the line between certain varieties of this class of rocks and those which have, in another section been spoken of, as hornblende schists. In this connection it is, as I have elsewhere pointed out, interesting to note that the darker, harder, more compact, and less chloritic hornblende schists are usually found at the base of the Keewatin series where the basal portion is in contact with the igneous granitoid gneiss of the Laurentian; while, when the base of the Keewatin rests upon the Coutchiching, the soft, fissile, light colored chloritic, green schists abound, and are also found in portions of the Keewatin removed from the contact with the Laurentian gneiss. The darker, harder, more compact, often glistening hornblende schists appear to be in part an altered phase of the fissile green schists, and the alteration further appears to be a function of their proximity to the Laurentian gneiss, which gneiss has all the characters of an igneous irruptive rock.

Swell Bay.

Only a few specimens of this class of rocks have been microscopically examined. On the shores of Swell Bay, these schists are found intercalated with the massive or slightly schistose altered traps. A specimen was taken from one of these beds about one mile east of the Bear's Passage. It is very fine-grained, greenish-grey schist, glossy on cleavage surfaces. In thin section (1604) it appears as an irregular aggregate of masses of fibrous hornblende, zoisite in colorless grains,

brownish-grey leucoxene in rounded grains, chlorite, quartz and calcite.

In another specimen (1605) taken at the same locality from another bed, the hornblende appears in needles and fibrous shred-like masses with a decided tendency to parallel arrangement. Chlorite is abundant. The other minerals are epidote, zoisite and leucoxene, none very abundant.

On an island in the north-east corner of Swell Bay the rock is a glossy, greenish-grey fissile schist made up in thin section (1616) of a fine-grained aggregate of quartz, fresh felspar, zoisite, decomposed biotite in parallel arrangement, and masses of chlorite in which are imbedded crystals of epidote. In contrast to this ground mass are large grains of calcite and leucoxene, with often opaque nuclei. Iron oxide stains the rock somewhat. The general aspect of the section is perhaps less like that of a volcanic ash than the other sections.

The fissile green schists of Grassy Lake on the Seine River are in thin section (49) seen to be comprised of chlorite, a few shreds of hornblende, an abundance of calcite and a little quartz, all in a more or less parallel arrangement. Grassy Lake.

On the north side of Bad Vermilion Lake a similar fissile schist occurs. It is composed (51) of an irregular mosaic of quartz, mixed with anastomosing areas of green, feebly pleochroic chlorite. Where the chlorite is in largest masses, it encloses crystals of colorless to yellowish epidote. The quartz contains liquid inclusions, often with a moving bubble and microlites of a highly refracting mineral, probably zircon. A little leucoxene with opaque nuclei, calcite and pyrite are the only other minerals. Veinules of epidote traverse the slide. Bad Vermilion Lake.

Another specimen of a similar schist from the N.E. end of the same lake (19) is a dark-green fissile rock, which, in thin section, appears to be made up mostly of quartz and chlorite. with large grains of calcite and some magnetite. All the constituents shew a parallel disposition.

A specimen of the dark-green fissile schists which are commonly interbedded with the altered traps on the north shore of Seine Bay, (17) is made up of quartz, felspar (in sparing quantity) hornblende and chlorite; with titanite, magnetite and epidote as accessory constituents. Some of the chlorite appears to be the result of the alteration of the hornblende, but for the most part its origin is indeterminate. The quartz and felspar form a mosaic ground-mass which, in places, is visible through the thin flocculent chlorite. The titanite is rather abundant in the usual double wedge-shaped crystals, and is disposed independently of the schistosity, which is evident in the arrangement of the other constituents. The crystals of titanite often have an opaque nucleus. The epidote is sparingly represented, and occurs in irregular grains. Seine Bay.

Conglomerates.

Interest attaching to these rocks.

These rocks are of extreme interest inasmuch as they not only give us a distinct criterion of the extent of the alteration which may be effected in strata of indisputably clastic origin, but also give us a clew as to the stratigraphical relations of the series of which they are members, to the underlying rocks. The nature of the pebbles, further affords us evidence as to the approximately original character of these latter rocks.

Rat-root Bay, Rainy Lake.

On the shores of Rat-root Bay, Rainy Lake, a formation of pebble conglomerate is well exposed and possesses strongly marked characters. The matrix is a rather soft, dark, glossy green, fissile chloritic schist. The pebbles are of a rather heterogeneous character and comprise smoothly rounded, distinctly water-worn pieces of glassy or saccharoidal quartz, pebbles of a somewhat foliated felspathic rock, and boulders of granite.

Granite boulder

A thin section (708) of a boulder of medium textured flesh-red granite imbedded in green schist on the south side of the bay appears under the microscope as a granular or allotriomorphic aggregate of orthoclase and plagioclase, with inclusions of apatite in the usual stout needles, quartz and biotite, with some accessory magnetite and secondary epidote. The felspars are cloudy, but the twinning lamellae of the plagioclase are quite distinct. The quartz has liquid inclusions arranged in streams. The biotite is frequently bleached or is altered to chlorite and epidote. Some fresh secondary biotite occurs as a rim around grains of magnetite. Leucoxene and limonite are present also in small quantities.

Granite boulder in schist, Swell Bay.

At the south-east corner of the end of Swell Bay, Rainy Lake, a granite boulder less than a foot in diameter was found imbedded in a fissile green schist which is interstratified with other green schists and with altered diabases. The granite is coarse-grained and of yellowish red color. Under the microscope (1618) it is remarkably fresh, and is made up of a granular aggregate of quartz, glassy orthoclase and plagioclase, with occasionally a micro-perthitic structure, and biotite. The accessory minerals are pleochroic titanite, apatite, magnetite and a little calcite. The orthoclase in exceptional spots is cloudy with muscovite. Radiating tufts of an actinolite-like mineral occur in the quartz. The plates of biotite are occasionally curved, and are often associated with and include crystals of titanite.

Seine River.

On the north side of Shoal Lake and Grassy Lake, on the Seine River, near the base of the Keewatin series where it rests on the Coutchiching, there is a formation of pebble and boulder conglomerate. The pebbles are mostly small, not exceeding, as a general rule, three

inches in longest diameter. Not infrequently, however, they are six inches or even a foot in diameter. They are distinctly water-worn and are oval or rounded in contour. They are imbedded in a fissile, glossy green, chloritic schist. The rocks have been evidently subjected to great pressure, to which must be ascribed the development of the schistosity in the matrix of the conglomerate; but owing to the great discrepency in resisting power between the pebbles and the matrix, the former have escaped deformation, while the latter has been much squeezed, as is shewn by the planes of schistosity bending around and conforming to the shape of the pebbles.

Pebbles. A thin section (3003 a) of one of these smooth, oval pebbles appears, under the microscope, as that of an altered felsite, being made up of a compact micro-crystalline aggregate of quartz and felspar, both striated and unstriated, in which a large amount of sericite has been secondarily developed.

A section (3003 b) of another similar pebble from the same conglomerate appears somewhat coarser in texture than the last, and partakes of the nature of a porphyry. In a very fine-grained base of quartz and felspar, in which have been developed much sericite and epidote, there are imbedded crystals of microcline with sharp well formed boundaries.

Pickerel Lake. On the west side of Pickerel Lake, Manitou Route, a band of felsitic agglomerate assumes locally the characters of a true conglomerate, in which a greenish schistose matrix holds rounded pebbles and angular fragments of quartz porphyry. A thin section (1044A) of one of these pebbles appears under the microscope, as a fine grained felsitic base in which are imbedded large porphyritic crystals of orthoclase, plagioclase and dihexahedral quartz, with a few tufts of fibrous hornblende. Veinules of secondary quartz in mosaics of large grains traverse the section.

Matrix of conglomerate. The matrix in which pebbles of this character are imbedded, is a green hornblende schist (1044), made up under the microscope of an intimate felt work of sheaf-like tufts of fresh green hornblende which appear to be imbedded in a transparent medium or base of quartz in small interlocking grains, together with calcite in large separate grains, and in mosaics with the quartz. Associated with the hornblende there is considerable magnetite in small grains.

Among the soft fissile glossy gray schists of the Keewatin series at the west end of Schist Lake, Pipe-stone route, there are several beds of conglomerate, the pebbles of which are mostly quartz rock, and the matrix a soft, more or less calcareous, decomposed schist, stained yellowish with oxide of iron.

Schist Lake conglomerate.

A thin section (217) was made across the line of contact of a pebble and its surrounding matrix. Under the microscope the matrix appears to be made up largely of calcite, muscovite in nests, quartz in aggregates of fine grains and in single fragments, and of irregular masses of brownish and red translucent iron oxide.

The pebble consists almost entirely of quartz in a very fine mosaic aggregate, partly chalcedonic. The line of contact of the pebble and matrix has been a channel of infiltration; for close to the contact there has been deposited in the quartz aggregate an abundance of minute scales of muscovite, which become less and less plentiful towards the centre of the pebble, and eventually disappear. Sharp little rhombs of calcite have, also, been deposited in the quartz rock pebble near the contact, and extend in stringers towards the centre of the pebble, but are entirely absent in its central portion. These rhombs of calcite are sometimes observed to have been developed around quartz grains, so as to quite include them, thus simulating on a microscopic scale the well-known phenomenon of the calcite of the Fontainbleau sandstone.

Discussion of conglomerates.

In considering these conglomerates with regard to the light they throw upon the mineralogical development of the rocks with which they are associated, upon the relations of the series of which they form a part to older series, and upon the original character of the older series from which the pebbles are presumably derived, the fact must be borne in mind, that they are intimately associated with rocks which are of undoubted volcanic origin, and are in fact but a subordinate portion of a voluminous volcanic series. Fissile green schists, such as usually form the matrix of these agglomerates are frequently found intercalated with the bedded traps of the series. They appear in these cases to be altered basic volcanic ash beds. And even where these rocks appear as the matrix of a true pebble conglomerate, it seems far more probable that these fissile green schists were originally volcanic débris composed of augitic and basic felspathic material, which has been subjected to the ordinary process of mineralogical alteration, giving rise to uralite, chlorite, epidote, calcite and quartz, than that they were ever clays which have by processes scarcely known to us, been crystallized into minerals which now compose the schists. The augite and plagioclase of the bedded diabases of the same series are very largely decomposed into the same minerals which make up the schistose matrix of the conglomerates.

Their presence in an overlying series, also, is evidence of an interval or geological break, during which the Coutchiching rocks suffered erosion; such break and erosion being indicative of unconformity between the Coutchiching and Keewatin.

The presence of granite boulders in these conglomerates is an interesting observation, but one which is susceptible of more than one explanation. Either the granites may have been torn from the shores of the trough in which the Keewatin rocks were being deposited by ordinary forces of rock disintegration, or they may have been brought up from beneath by volcanic forces. It is altogether probable, however, that they indicate the existence of subaërial granite at the time of the deposition of the Keewatin rocks; and although all the granites of the region appear to be in some degree later than the Keewatin rocks, this does not necessarily conflict with the supposition of a granite shore for the basin in which the Keewatin rocks were deposited. A study of the region leaves no room for doubt in my own mind but that the original floor of the basin upon which the Keewatin and Coutchiching rocks were deposited, whether it were granite or any other rock, was fused in times of disturbance, and appears now to us as the foliated granite known as the Laurentian gneiss. Thus the granite boulders in the Keewatin agglomerates may have been derived from a granite basement now obliterated by subsequent plutonic fusion.

Granite boulders in conglomerates.

The felsites and quartz-porphyries which, as smooth, well rounded or oval, waterworn pebbles, are so largely represented in the Keewatin conglomerates, have no known analogues within the district examined in the underlying Coutchiching or Laurentian rocks. But if the Laurentian were fused at a time subsequent to the deposition of either the Coutchiching or Keewatin, these pebbles may possibly represent the condition of a portion of these rocks as they existed prior to the fusion. Or, these felsites and quartz porphyry pebbles may have been derived from the underlying Coutchiching series, and represent the original character of part of the rocks of that series. The alteration of quartz-porphyries and felsites would readily yield, under the influence of great pressure, the fine grained, evenly laminated, grey gneiss which is now found interbedded with mica schists in the Coutchiching series. The alteration would be quite analogous to that worked out by Lehmann*, for the derivation of the granulitic gneisses of Saxony, from quartz-porphyries. No direct evidence has, however, been observed of volcanic agencies having had a part in the building up of the Coutchiching series.

Sericite Schists, Felsitic Schists—Altered Quartz-Porphyries.

The rocks of the Keewatin series which, in field parlance, are referred to as felsitic schists, but which, in strict nomenclature, are for the greater part altered quartz-porphyries, occur sometimes as formations of enormous thickness, occupying extensive areas, and sometimes as

Mode of occurrence.

* Ueber die Entstehung der Altkrystalliner schiefer gesteine. Bonn, 1884.

comparatively insignificant beds as little as a foot in thickness, intercalated with green schists. They are usually evenly stratiform in aspect, and by the development of secondary minerals as a concomitant of dynamic crushing and stretching, they pass on the one hand into the porphyroids and nacreous or glossy sericitic schists, and on the other, into granulitic biotite gneisses. They have very frequently associated with them acid volcanic tuffs and agglomerates, in which the paste appears to be simply the débris of the quartz-porphyry material, while the included fragments are, as a general rule, pieces of the massive rock. These quartz-porphyries are interesting geognostically in the fact that they represent a wide-spread extravasation of acid volcanic rocks, subsequent to the extravasation of the basic, volcanic rocks (diabases) which make up so large a part of the underlying or basal members of the Keewatin series in this region. From a petrographical standpoint they are interesting for the clear and unmistakable way in which they reveal the effects of rock-crushing and stretching, in the sundering of the felspars and quartzes, and the frequent reduction of the latter by granulation to lenses with tapering tails, as well as by the development of mica along the shearing planes, and its curvature around the porphyritic constitutents of the rock.

Sequence of acid after basic rocks.

Line Bay, Pipestone Lake.

No. 378.—On the east side of Line Bay, Pipestone Lake, in narrow bands, one to three feet wide, apparently imbedded with the green schists. The rock is a silver grey "porphyroid" sericite schist. Under the microscope it appears to be made up of a fine-grained ground mass of quartz and felspar, in which have been developed scattered scales of muscovite. In this are imbedded grains and crystals of varying size of quartz and felspar. These porphyritic constituents either retain the characteristic shape of felspar or the dihexahedral forms of quartz, or are in the form of lenses arranged with their long axes parallel. Besides the scattered scales of muscovite throughout the ground mass, there is a much more abundant development of that mineral along broad wavy parallel bands, which traverse the schists and flow around the porphyritic crystals. These lines, along which the muscovite has been so largely developed, would appear to have been shearing planes. These bands of muscovite, although flowing around the porphyritic crystals, rarely completely enclose them. For in the wake of the fragment or crystal there is usually congregated together a number of minute grains of felspar and quartz which, in some cases, appear to be a portion of the ground mass, which, in the shearing, has moved with the porphyritic grain in its shelter or shadow, and in others to be the result of the granulation of the larger mass. The muscovite in the wavy bands exists to the entire displacement of the ground mass; and would thus appear to have been developed during the

process of slipping and rending, the proof of which is seen in the dislocation and sundering of the porphyritic constituents, the cracks being filled with the ground mass and muscovite. The scales of the

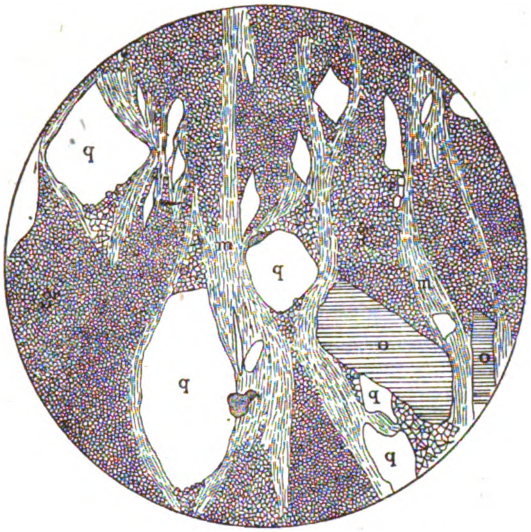


Fig. 8.—Section of porphyroid sericite schist (altered quartz-porphyry) from Line Bay, Pipestone Lake, showing more or less parallel bands of muscovite, (m) running through the rock and flowing around the porphyritic crystals of quartz, (q) and orthoclase, (o) some of which are reduced to lenses having their long axes approximately parallel. × 44.

muscovite of the wavy bands are, at any particular place, strictly parallel and closely compacted, so that the band extinguishes as a unit for as much of its length as may coincide with a section of the nicols. The relation of these bands of muscovite to the ground mass and to the porphyritic crystals is illustrated in Fig. 8 drawn with the camera lucida.

No. 1784.—South end of Clear-water Lake, Kishkutena route, west side. A flesh-tinted to purplish crypto-crystalline schist, with occasional porphyritic crystals of felspar, and with chlorite developed along the cleavage surfaces. Under the microscope, seen to be made up of a fine-grained ground mass of quartz and felspar, throughout which are disseminated the secondary minerals muscovite, chlorite, epidote and calcite. In this are imbedded large usually broken fragments of orthoclase and plagioclase, and areas of granulated quartz. Chlorite has been developed along the shearing planes. Clearwater Lake.

No. 1786.—Half a mile west of last locality at south end of Clear-water Lake. Light grey crypto-crystalline schist with rough, unctuous South end of lake.

cleavage surfaces, resembling the last in its microscopic character, particularly in the ground mass. The porphyritic constituents are crystals and broken fragments of felspar, and granulated lenses of quartz, indicative of intense crushing and stretching action. A large amount of muscovite has been developed in parallel position and frequently flows around the porphyritic grains. Small amounts of chlorite and calcite are scattered through the rock.

West side of lake.

No. 1788.—West side of Clearwater Lake, towards the south end. A greenish-grey to yellowish quartz-porphyry, carrying large masses of quartz and felspar, in which have been developed considerable muscovite and some chlorite, and in which are imbedded in porphyritic development, orthoclase, plagioclase and quartz. The felspars usually occur in well defined, crystalline forms, but are frequently dislocated and sundered. They are largely decomposed to kaolin, muscovite and epidote. The quartz occurs in irregular grains and in more or less dodecahedral forms, which are often seen to have corrosion bays of the ground mass running into them; or to be parted, the fissures being filled with the ground mass.

Hazy Point.

No. 1791.—South side of Hazy Point, Clear-water Lake. A flesh tinted to purplish quartz-porphyry, made up of a fine-grained ground mass of quartz and felspar, in which have been developed considerable muscovite in minute scales and a little chlorite, calcite and secondary quartz. In this are imbedded large porphyritic crystals of orthoclase, plagioclase, entire and in broken pieces, and quartz usually in lenses with granular margins. The long axis of the felspars and of the quartz lenses are parallel, and there is a flow structure of the muscovite and chlorite around them. There is present also a little epidote resulting from the decomposition of the plagioclase.

East side of lake.

No. 1829.—South end of Clear-water Lake, east side. Grey quartz-porphyry merging in the field into a gneiss by the development of biotite in parallel position. Under the microscope, it appears as a fine-ground mass of quartz and felspar, with considerable quantities of epidote, muscovite and a little calcite. In this are imbedded crystals of orthoclase, plagioclase, quartz, muscovite and biotite. The orthoclase is in Carlsbad twins, and the plagioclase in the usual polysynthetic twins of the albite type. They are usually rounded or sub-angular in outline, though they are occasionally met with in sharp, crystal forms. The quartz is in irregular grains, and in more or less rounded dodecahedral crystals. The muscovite and biotite are only sparingly present in rather thick plates.

S. of Burnt Narrows.

No. 1841.—South end of Clear-water Lake, east side, half a mile south of Burnt Narrows. This rock has the aspect of a micaceous granulitic gneiss, but is probably an altered form of the quartz por-

phyries with which it is associated. It is made up of a fine-ground mass of quartz and felspar, in grains, which, with high powers, are observed to be more or less rounded or granulitic, and the constituent grains appear to be larger than those of the ground mass of the quartz porphyries, above described. The porphyritic crystals are only observable in irregular and vague traces, with often a granular border. The porphyritic quartz is less abundant than the felspar. Biotite in irregular plates of varying size, but parallel in position, is scattered throughout the rock, together with a smaller number of rather large plates of muscovite.

No. 2023.—South side of Off Lake. In association with the acid clastic tuffs, 2019, 2021 and 2022. Macroscopically, a purplish, crypto-crystalline sericitic schist. Under the microscope, it presents a fine ground-mass of quartz and felspar, throughout which an abundance of muscovite has been developed, and epidote in lenticular nests. In this are imbedded crystals of orthoclase in Carlsbad twins, plagioclase, and Off Lake.

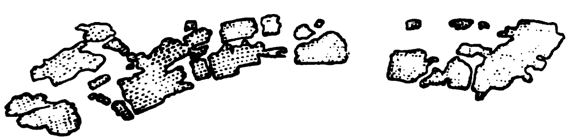


Fig. 9.—Sundered crystal of tourmaline in quartz-porphyry from south side of Off Lake. × 11.

quartz generally in lenses with granulated margins. A crystal of tourmaline was observed in a long prism, showing the sundering or stretching effects manifested elsewhere in this rock. The sundered aspect of the tourmaline is shewn in Fig. 9. It does not appear to have been a completely developed crystal, but the separation of the once continuous parts is nevertheless quite apparent. The crystal is strongly pleochroic, ω very dark-green to greenish blue, ϵ very light brown.

No. 997.—West side of Pickerel Lake, north of Cedar Narrows, Manitou route. A light bluish-grey, quartzose schist of fine sugary texture, with large porphyritic blebs of quartz. Under the microscope, it appears as a fine-grained ground mass of quartz and felspar, throughout which shreds of muscovite are plentifully scattered, together with irregular aggregates of grains of epidote and a little calcite. In this ground mass are imbedded large grains of quartz, some of which have distinct dodecahedral outlines which give the rock the characters of a quartz porphyry. Pickerel Lake.

No. 1001.—West side of Pickerel Lake, one mile north of Cedar Narrows. A grey aphanitic rock in which are imbedded grains of quartz One mile N. of Cedar Narrows.

and crystals of felspar. Under the microscope, constituents of three generations are represented by three grades of fineness. The predominant of these are the grains of the second géneration which consist of quartz and non-striated felspar in uniform-sized grains from ·1 to ·2 mm. in diameter. These are sometimes so closely packed as to leave no interstitial space, more frequently, however, there is an interstitial space between the grains, which is filled by the material of the third generation, which comprises grains of felspar and quartz from ·01 to ·04 mm. in size. The constituents of the second and third generations together with grains of epidote, shreds of muscovite, and a little leucoxene, make up a ground mass in which are imbedded large grains of quartz, crystals of orthoclase twinned on the Carlsbad law and filled with sharp little scales of muscovite and crystals of plagioclase twinned on the albite law, and largely altered to epidote. There is throughout a well marked flow structure manifested, seen in the bending of streams or bands of muscovite around the porphyritic grains which are further sometimes torn asunder.

Swell Bay. No. 54.—South shore, Swell Bay, one mile N. E. of Little Rocky Narrows. A dark grey crypto-crystalline schist made up of a fine-grained base of quartz and felspar grains of varying size, in which has been developed considerable muscovite. Coarser mosaic linear areas alternate roughly with finer or more sericitic areas, giving the rock a schistose or banded structure. In this base are imbedded grains of quartz, some of which are rounded or crushed into granulated lenses while others retain their dihexahedral form quite distinctly. Fresh biotite is observed to have been developed along shearing planes in the wake of the crushed or granulated quartzes. A good deal of calcite is interspersed throughout the base, and occasionally replaces the felspar.

No. 1619.—South shore, Swell Bay, near east end. A yellowish grey, feebly banded aphanitic schist, with sericitic gloss on cleavage surfaces. A very much squeezed and drawn out rock made up of a fine ground mass of quartz and felspar, with considerable muscovite arranged in streams or flowing bands along shearing lines. In this are imbedded grains of magnetite and lenses of granulated quartz, with liquid and dirty inclusions, so altered that it might possibly have been a quartz porphyry tuff rather than the massive rock itself.

Sturgeon Falls. No. 52.—Sturgeon Falls, Seine River. A glossy, grey, porphyroid schist made up of a very fine felsitic ground mass, in which has been developed an abundance of muscovite, and porphyritic crystals of orthoclase and plagioclase, both very cloudy, with irregular or pear shaped grains of quartz with undulatory extinction. There is a good deal of calcite in large individuals present as well as a considerable amount of fresh biotite, developed along parallel lines which probably represent shearing planes.

Fragmental Rocks—Grauwackes—Volcanic Tuffs, etc.

Besides the conglomerates and those fissile green schists which appear to be altered augitic volcanic ash beds, there are voluminous formations of other fragmental rocks which form prominent members of the Keewatin series in the region under consideration. These fall into two main types which, however, both in their conditions of occurrence and in their petrographical characters are closely associated (1) grits or grauwackes, generally very distinctly bedded, varying in color from light-yellowish grey to very dark grey and presenting varying degrees of texture. These have sometimes the characters of quartzites, and occur generally on the same horizons with felsitic schists, from which they cannot be separated for purposes of mapping. (2) Volcanic agglomerates or tuffs, generally extremely felspathic, and having a paste quite similar, in many cases, to the grauwackes. The included fragments are, for the most part, either sharply angular or lenticular, and composed of a very felspathic rock, often a quartz-porphyry, which is usually of lighter color than the paste. The lenticular aspect of the fragments appears to be intimately associated with a pronounced schistosity of the rock, and is doubtless the result of deformation due to pressure. There is throughout the region a notable paucity of those greener or more hornblendic varieties of the agglomerates which were observed on the Lake of the Woods. Micaceous varieties are also not well represented. The agglomerates of the Rainy Lake region are remarkably uniform in their highly felspathic character, but are quite the same as the more felspathic varieties observed on the Lake of the Woods. A somewhat detailed account of the characters of a few specimens of these fragmental rocks will be of more immediate interest than any general statements that may be made concerning them.

Two types of these rocks.

First type.

Second type.

On the south side of Crow Lake there is an extensive development of bedded fragmental rocks, most of which being felspathic rather than quartzose, and having their constituent grains angular, rather than rounded, may be termed grauwackes. Some of them are, however, very quartzose, and of the character of indurated sandstones. The finer grained of these are probably partially of volcanic origin, i.e., the direct débris of volcanic material, and partially of sedimentary origin. A specimen (109) from the south side of Patch Island is a very fine-grained, dark grey, evenly banded, hard rock, with a brittle, conchoidal fracture. Under the microscope, it has a well marked clastic structure, being made up chiefly of angular broken fragments of quartz of varying size. Occasionally, the grains are rounded or pear-shaped. The rock shows the banding or bedding in the thin section, the demarkation between the different layers being an irregular wavy

South side Crow Lake.

line, along which has been deposited a finely granular, almost opaque material, probably iron oxide. Minute grains of epidote, pale green flakes of chlorite, and shreds of muscovite, are present, with a little leucoxene.

Patch Island. Half a mile west of Patch Island a little grey massive rock with blades of chlorite occurs. Under the microscope (98) it appears to be made up chiefly of angular, sub-angular and occasionally rounded grains of plagioclase containing needles of apatite, and quite fresh save for the presence of a few grains of epidote and shreds of muscovite. Larger grains of epidote and calcite are generally distributed through the section, together with a little leucoxene. Micaceous chlorite occurs in large patches as if pseudomorphic, after some pyroxenic mineral and pyrite with decomposition rims of limonite.

S.E. of Chase Point. Two miles south-east of Chase Point, on the south shore of Crow Lake, the rock is a grey to a yellowish white grauwacke, evenly bedded. Under the microscope (125) it is made up of a fine-grained ground-mass of more or less rounded grains of quartz and felspar, in which are imbedded large fragments of plagioclase, orthoclase and quartz. The section is cloudy with aggregations of kaolin and epidote. Well defined individuals of epidote also occur. Other secondary minerals are: quartz in mosaics, calcite in occasional grains, sometimes replacing the felspar, muscovite in minute scales, a little limonite and some elongated shreds of fibrous hornblende.

Shanty Point. On the shores of the bay east of Shanty Point, an agglomerate or tuff occurs, the finer-grained base which, under the microscope (146) is made up of a paste of minute particles of quartz and felspar, in which are imbedded angular fragments of the same minerals which have sometimes a jagged outline with sharp re-entrant angles. The plagioclase is spotted with small quantities of muscovite, epidote and zoisite. Shreds of hornblende with epidote are generally disseminated, as well as an abundance of epidote, unassociated with the hornblende, in single grains and in nests of grains.

Pipestone Lake Unde Rapids. At the south end Unde Rapids between Schist Lake and Pipestone Lake, a grey to yellowish compact rock occurs with whitish weathering. Under the microscope (234) it appears as a fine-grained ground mass of felspar and quartz, with interspersed scales of muscovite and grains of epidote, in which are imbedded rounded and angular fragments of plagioclase and quartz. The most prominent mineral in the rock, however, is calcite, which has been developed *in situ* in beautifully sharp rhombs. The calcite is also seen partially replacing the plagioclase fragments, and occasionally a well defined rhomb of that mineral occurs in the heart of a felspar grain. The calcite has occasionally a nucleus of almost opaque granular material.

On Pipestone Lake, half a mile west of Pivot Point, north side, a specimen was taken of a greenish grey clastic rock, which in thin section (286) is seen to be made up of a fine-grained paste of quartz grains, shreds of muscovite and chlorite and grains of epidote. In this are imbedded rounded and angular grains of quartz and some leucoxene. Pyrite and calcite are prominent secondary minerals. That the rock has yielded to pressure is indicated not only macroscopically by its schistosity, but also microscopically by the breaking and sundering of the quartz grains and the drawing out of the leucoxene into long stringers. W. of Pivot Point.

A quarter of a mile west of the last locality, a dark green, rudely schistose chloritic rock, spotted with fragments of quartz, occupies the shore. Under the microscope (266) it is made up of a matrix of

Fig. 10.—Fragmental rock from from near Pivot Point, Pipestone Lake, shewing sundering of individual of quartz, (q, q, q) into several pieces. Rending effects also seen in leucoxene (l), (q) quartz grains other than the sundered individual. The base of the rock is chlorite, (ch) in which, subsequent to pressure, have been developed sharp rhombs of calcite or dolomite. × 18.

chlorite and quartz in fine grains. In this are imbedded large rounded and angular fragments of quartz, felspar and leucoxene. The rock shews pressure effects to a remarkable degree, the quartz grains frequently being torn asunder into numerous fragments shewing the same, or approximately the same, extinction. The spaces between these sundered fragments are filled with chlorite, the scales of which are in Pressure effects

definite parallel position corresponding to the schist planes. The leucoxene shows the same sundering, though in a less degree. Felspar grains are abundant. Beautifully sharp calcites have been developed in the chloritic base of the rock, apparently at a period subsequent to the action of the pressure. The various features here described are illustrated in Fig. 10.

Three-quarters of a mile west of Pivot Point, on the south side, the rock (277) is a grey schist made up of a fine-grained ground mass of quartz grains and shreds of muscovite in parallel position with patches of chlorite and grains of epidote. In this are imbedded larger, rounded and pear-shaped grains of quartz, with occasionally more angular pieces. Aggregates of muscovite are massed together in parallel position, in areas having an oblong shape, apparently constituting a pseudomorph, after felspar. Scattered through the section are rhombs and irregular masses of calcite and magnetite in grains or loose lenticular aggregates of grains.

S.E. side of lake.

On the south-east side of Pipestone Lake there occur some subordinate beds of a grey-green, fine grained, though not uniformly textured rock, having a well marked schistose structure. It (356) is made up chiefly of small angular and sub-angular grains of quartz, shreds of partially bleached biotite in parallel arrangement, large and small grains and aggregates of grains of epidote, with areas of mosaic quartz and calcite of large grain, and a few crystals of pyrite.

Pickerel Lake, north end.

At the north end of Pickerel Lake, Manitou route, there is a large volume of compact, dark-grey quartzose, clastic slates, passing across the strike into fine grained clay slates. A thin section of this rock (1011) from the west side of the lake, shews it to be distinctly banded and made up chiefly of quartz in more or less rounded grains, with generally a black rim around the periphery where in contact with other grains. Over this are scattered cloud-like patches of yellowish-green isotropic chloritic material, and an abundance of opaque (carbonaceous) matter in irregular grains and ragged shreds. Grains of leucoxene with opaque nuclei and small plates of muscovite are also present. Microlites of apatite and zircon are included in the quartz.

East side of lake.

On the east side of the lake, another specimen of the same rock formation presents in thin section (1022) to the naked eye, or with a low power, a spotted appearance, due to the presence of round or pear-shaped areas, in rough parallel arrangement, which are clearer and more transparent than the rest of the rock. The base of the rock is an aggregate of minute quartz grains, intermixed with which is a considerable amount of finely divided opaque matter, probably carbonaceous. The rounded and pear-shaped clear spots are areas where there is a much less amount of carbonaceous matter, and where mus-

covite has been developed in little nests to its exclusion. The border of these clear areas is a comparatively sharp one. Muscovite in large plates and a little flocculent chlorite are also scattered throughout the section. The differentiation in the distribution of the carbonaceous matter recalls that in the Steiger Schiefer of the Barr-Andlau contact zone described by Rosenbusch,* although the process appears to be the reverse of that there observed; being an elimination of the carbon from certain areas, not its condensation into "Knötchen." The specimen described is from the proximity of the most easterly of the two granite bosses on Pickerel Lake.

Another specimen (1023) from the same formation near the same granite boss is a fine grained compact rock, made up of a fine quartzose base, through which are scattered small plates and ragged shreds of biotite of pale, greenish-brown color, and colorless muscovite, with occasional crystals of pyrite, the decomposition of which has stained the rock yellowish.

On the south side of the lower end of Manitou Lake, the rock is **Manitou Lake.** a much finer grained and more slaty or fissile phase of the same formation as that from which the specimens just described were taken. It (1077) resembles the last in microscopic structure. Under low powers of the microscope it shews a distinctly marked lenticular structure identical in miniature aspect with that shewn by glaciated sections of squeezed agglomerates on the large scale. The lenticular areas are more transparent than the base of the rock. This base is made up of an irregular aggregate of quartz, actinolite (almost colorless), muscovite and calcite. Scattered through it and rendering it cloudy is a large amount of a grey, granular, semi-translucent substance resembling the product of the kaolinization of felspar. With high powers these grains in ordinary light are transparent, but almost opaque between crossed nicols. It is the absence of this cloudy granular material in the lenticular areas of the section that render them so transparent and prominent, since they do not appear to otherwise differ greatly from the rest of the rock.

On the west side of Clearwater Lake, Kishkutena route there is an **Clearwater Lake.** extensive formation of felsitic (quartz-porphyry) agglomerate. A specimen taken from the shore one mile north of Hazy Point, appears as a greenish, clastic rock, or quartz-porphyry tuff, in which are included large angular and lens-shaped masses of flesh-tinted quartz-porphyry. Under the microscope, a section of one of these inclusions (1796) is that of a typical quartz-porphyry, shewing a fine grained, ground mass of quartz and felspar, in which have been developed secondary muscovite and a little epidote. The porphyritic minerals are orthoclase, plagioclase

* Mikr. Phys. der mass. Gestein. Stuttgart, 1886, p. 47.

and a few grains of quartz. The felspars are in well defined crystal forms, although some are broken.

The matrix of the agglomerate shews also a fine grained ground mass of quartz and felspar, but the grains are not of such uniform size, nor the structure of the rock so compact, as in the case of the porphyry. There is much more epidote, muscovite, calcite and chlorite; and in the porphyritic or pseudo-porphyritic grains, the felspar is much more fragmental or broken in character, and there is an abundance of irregularly shaped grains of quartz. It also shews a foliated structure, and might be mistaken for a much crushed quartz-porphyry, were it not for its association and known clastic origin.

Off Lake.

On the west shores of Off Lake, on the west side of the Kishkutena route, there occurs a coarse fragmental rock of a yellowish to greenish color, which under the microscope, (2019) is made up of an indiscriminate aggregate of quartz and felspar in angular fragments, with irregular shaped nests of epidote and chlorite, apparently the results of decomposition of included chips of a basic rock.

Pseudo-gneissic structure.

Farther along the shore to the southward, the rock passes into a more uniformly textured rock of yellow color, which has developed in it a well marked pseudo-gneissic structure. Under the microscope (2021) the rock appears to be much the same as that last described, but shews pressure and pulling effects to a remarkable degree. The quartz grains are reduced to long lenses surrounded by a granular border which runs out into a tapering tail at each end. The lenses all shew a decided undulatory extinction due to unequal tension. The granules surrounding these lenses closely interlock, and are freer of inclusions than the lens itself, indicating a re-crystallization of the grains as part of the process of granulation. These quartz lenses, with their granulated borders, tapering tails, and undulatory extinction correspond exactly with those described by Lehmann in some of the rocks of Saxony, as a result of pressure.* The felspars are shattered and torn apart. A considerable amount of muscovite, chlorite and epidote has been developed in the rock, and these minerals, together with the quartz lenses are all in parallel arrangement, giving rise to its gneissic aspect.

Resemblance to rocks of Saxony described by Lehmann.

On the south side of the lake the rock is still more gneissic in aspect, and under the microscope (2022) appears much more altered. It is made up of orthoclase, plagioclase and quartz. The felspars are in grains of usually crushed or lenticular appearance, with some broken fragments of less regular contours. The quartz is in mosaics, arranged in parallel stripes which appear to represent the granulation of large grains of quartz carried to an extreme. Larger lenses of quartz, with

* Cf. Intersuch. über die Entstehung der altkrystallinischen Schiefergesteine, p. 250.

granulated margins and tails are also observable. Muscovite and epidote are abundant and are generally arranged in long, narrow areas or in stripes in parallel position.

On the south shore of Rainy Lake, and on the off-lying islands in the neighborhood of Grind-stone Narrows, there occur rocks of clastic origin which appear, in some places, to be simply altered sandstones, while at others they are very felspathic, schistose and glossy, and are associated with occasional beds of agglomerate and true conglomerate. A specimen (743) from the shore of the lake one mile west of Grind-stone Narrows, appears, under the microscope, as a fine grained matrix of quartz, epidote, muscovite and felspar, in which are imbedded large and small broken fragments of quartz and plagioclase, which are usually quite sharply angular, though sometimes rounded. These fragments of quartz are full of fluid inclusions which are, for the most part, arranged in rows or streams. The other minerals present are magnetite, limonite and leucoxene in sporadic grains. **Grind-stone Narrows.**

At Grind-stone Narrows the rock is a yellowish, quartzose schist made up, as seen in thin section (749), of a clastic aggregate of quartz and felspar grains of a generally angular or sub-angular shape, imbedded in a paste made up of the same minerals in a more finely divided state, and cemented by secondary minerals such as quartz, calcite, muscovite, chlorite, limonite and epidote.

Peridotites and Gabbros.

Peridotite rocks are very poorly represented in the Rainy Lake region. They have been observed at only a few localities, and in these they occur in the extremely altered forms known as serpentine. They occur only in the Keewatin series, but their relations to the rocks adjoining them are ill defined, and have not been altogether satisfactorily determined. They appear, however, to be the alteration products of igneous masses which are of the same geological age as the traps and other volcanic rocks of the Keewatin series; and although their common boss-like character suggests that they are intrusive through the Keewatin rocks, such intrusion has probably taken place coeval with the bedded formations, volcanic and sedimentary, of the Keewatin. **Peridotites not abundant.** **Their geological relations.**

One of these bosses of serpentine, apparently of quite small extent, occurs on the N. E. extremity of the point of land that projects into Crow Lake from the west side midway between Crow Portage and Wade Portage. The rock is of a fine, compact texture, and has a mottled, light and dark green aspect and shows a yellow weathered surface. It is associated with green altered traps and green schists. **Crow Lake serpentine.**

Little can be determined from the microscopic examination of the rock (24) as to its original character. It is seen to be made up of rounded or sub-angular grains, now composed entirely of serpentine of a pale green color, but probably originally composed of olivine. Between these grains there is considerable interstitial calcite and a little chlorite, while granular or dusty magnetite is disseminated throughout the section.

Clear-water Lake.

On Clear-water Lake, Kishkutena route, the west shore of the lake, for a distance of about a mile south from the 49th parallel is occupied by a similar rock, which was observed to be traversed by small veins of coarsely fibrous serpentine or picrolite.

Serpentine of Lake Despair

Another locality at which this class of rock was observed is at the bottom of the South Bay of Lake Despair, to the west of the North-west Bay of Rainy Lake. Here it occupies the shore for the space of between a quarter and half a mile, with black hornblende schists on either side. Its relations to these schists could not be studied at the time the locality was visited, from the fact that the woods were on fire close down to the water's edge, and it was with difficulty that a few specimens could be secured. Two varieties of somewhat different aspect were observed in the same mass. One of these (1741) is a purplish, green, compact serpentine, speckled with glistening facets of mica. It weathers on exposed surfaces to a dull red color. Under the microscope, the only minerals that can be detected now are serpentine, magnetite and white mica. It is probably an extremely altered form of an olivine-enstatite rock of coarse-grained texture. The only traces of these minerals, however, that are now observable are the rounded or double-domed outlines of the one with fine dusty magnetite, heaped together in the middle, and the oblong nearly rectangular forms of the other with the cleavage lines still remaining. The magnetite is occasionally in distinct octahedra, but generally it occurs in irregular granules, and is nearly always associated with a mica which is either colorless, or pale green and pleochroic; some of it polarizes brilliantly and some in quieter colors, such as brown and grey. It all, however, gives a biaxial interference figure in converged polarized light, a fact which determines it as muscovite, and not bleached biotite, as might be suspected from its association with the iron oxide. The less brilliantly polarizing varieties shew between crossed nicols, the peculiar bird's-eye-maple mottling so characteristic of the micas.

First variety.

Second variety.

The second variety (1742) of serpentine taken from this occurrence on Lake Despair, has a mottled aspect of a greenish, black base and silvery grey spots. Its microscopic aspect resembles that of the specimen just described, in all respects, except that there is an abundance of grey leucoxene. This often shews opaque nuclei of magnetite or titanic iron, but is more commonly without such nuclei.

On the north side of the south-east arm of Crow Lake there is boss-like area of gabbro which, in places, appears to be entirely altered to serpentine although retaining, for the most part, its granular character. A specimen of the less altered part of this mass appears in thin section (46 A) to be an olivine, hypersthene gabbro. It is composed of hypersthene, olivine, diallage and plagioclase. The hypersthene is the most abundant, the diallage and plagioclase are the least abundant, and occur in about equal proportions. The hypersthene is quite fresh and shews its characteristic pleochroism very strongly. Neither it nor the diallage are bounded by crystallographic contours, but are allotriomorphic. The olivine is in more or less well defined crystals, with characteristic dome faces, but is more than half altered to serpentine, anastomosing veins of which traverse the olivine in all directions. The plagioclase is in cloudy, lath-shaped, polysynthetically twinned crystals, and in small oval bodies included in the hypersthene. There is associated with the hypersthene a considerable proportion of magnetite. **Crow Lake olivine gabbro**

The area of gabbro which is exposed on the shores of Bad Vermilion Lake and River, differs from that just described from Crow Lake in the fact that plagioclase was, in the original rock, the dominant mineral, while the olivine and pyroxenic minerals were very sparingly represented. Thus, under process of decay and alteration, the rock has assumed, not the form of serpentine but that of saussurite, the condition determining the difference being doubtless the proportion of magnesia and iron in the original magma. The gabbro on Bad Vermilion Lake is, in many places, a fine white rock resembling at first sight a coarsely crystalline marble. It is, however, much harder, and is for the most part mottled, with the pyroxenic constituent. Under the microscope (47) there is little to be noted, save that the anorthite is almost entirely changed to the aggregate of zoisite and albite, known as saussurite, and that the pyroxene is non-pleochroic and rhombic, though much decomposed, and difficult to determine accurately. **Saussurite gabbro of Bad Vermilion Lake.**

In another section (2154) calcite is a prominent constituent of the saussurite, besides the zoisite and albite, and the pyroxenic constituent is altered entirely into serpentine in nests or aggregates of small grains.

THE COUTCHICHING SERIES.

Around the east arm of Rainy Lake there is an enormously thick series of schists of remarkably uniform character underlying the Keewatin series. They are composed chiefly of quartz and biotite, with or without felspar, and are distinctly bedded in layers of varying **Geological position of series—its bedded character.**

thickness, and in such a manner that it is difficult to resist the conclusion that the layers are the result of original deposition.

Section on shores of Rainy Lake and Nameukan Lake.

The series is best studied in its stratigraphical aspects in the excellent natural section afforded by the shores of the lake, on the Canadian side, from Bleak Bay to Kettle Falls and thence across Nameukan Lake to Sand Point Lake. Throughout this distance, about twenty-four miles in a direction more or less obliquely transverse to the strike, only the upturned edges of the beds of the Coutchiching series are seen, the dip varying from almost horizontal to quite vertical. The only interruptions are a few small intrusions of gneiss or granite which traverse the rocks in the neighborhood of the axes of folding.

Breadth of belt.

The breadth of the belt from Bleak Bay to Sand Point Lake, in a direction directly transverse to the strike is about eighteen miles. The limit of the belt on the north is its contact with the Keewatin rocks along the edge of the trough which runs down the Seine River and across Rainy Lake to the bottom of Rat-root Bay. Its southern limit is its contact with an area of gneiss and granite of which the full extent is not yet known, but which has been traced on the shores of the International Boundary canoe route as far as the east side of Basswood Lake. Within these limits this belt of the Coutchiching rocks comprises a three-fold repetition of the full volume of the series; and two axes of folding, one an anticlinal and the other a synclinal are clearly indicated.

Three-fold repetition of volume.

For six miles and a half southward from the northern limit of the belt of the Coutchiching series the dips are continuously to the north or under the above mentioned Keewatin trough, at angles which range from 15° to 85°. Then we come upon a line along which the rocks are in a perfectly vertical attitude, and to the south of which they dip southward. This line is taken to be the axis of a great anticlinal fold. It intersects the shore at a point midway between the mouth of the Rat River and Vague Point.

Anticlinal axis.

Similar disposition of rocks on United States side of the Lake.

A precisely similar disposition is observed in the section afforded by the shores of the lake on the United States side. From their contact with the Keewatin rocks, near the mouth of Black Bay, to the Brulé Narrows, the Coutchiching rocks run in continuous exposure, striking with the general trend of the shore and with a prevailing northerly dip at angles varying from 50° or 55° to 90°. At Cranberry Bay it is about vertical. After rounding Point Observe at Brulé Narrows and entering Saginaw Bay, it becomes lower and lower, the direction, however, of both dip and strike remaining constant. With the exception of an unimportant local or intermediate fold observable at the southwest corner of Saginaw Bay, this northerly dip at low angles is constant on all the shores and islands of the bay. South of Pine Islands, the dip

gradually becomes steeper, and at the Narrows between Big Island and the south shore, a line is reached along which the dip is vertical. This is the same axis as that observed between the mouth of Rat River and Vague Point. It is again found on the line of section afforded by the Pipestone River, about one mile up stream, the dip on the north side being distinctly northward, and on the south, southward. The total distance through which this axis is thus traceable is sixteen miles, and judging from the uniformity of structure it probably extends very much further. In the vicinity of this axis and to the south of it, on the islands and especially the south shore of the lake, there are numerous intrusions of granitoid gneiss and of a very coarse muscovite granite, in which the constituent crystals are often several inches in diameter. These are most prominent on the islands to the south and south-west of Vague Point and in the neighborhood of Big Island, as well as on the south shore east of Big Island.

Pipestone River section.

South of the axis the strata continue to dip south, to a line drawn parallel to the strike through Kettle Falls. This latter line constitutes a synclinal axis, the rocks to the south of it all having a southerly dip. The distance between the anticlinal and synclinal axis is about four miles and three-quarters. The distance between the Kettle Falls syncline and the southern limit of this belt of Coutchiching rocks where it comes against the granite and gneiss of Sand Point Lake is about six miles and three-quarters. In this three-fold repetition of the volume of the Coutchiching series an unusually good opportunity of forming an estimate of the thickness of the series is afforded, owing to the simplicity of the folding. In the first six miles and a half of the belt, from its northern limit southward to the anticlinal axis it is difficult to form an estimate of the average dip. The whole distance may, however, be divided into five portions, in each of which the average dip may be estimated with comparative accuracy, and the total thickness thus deduced be taken as that of the series. At the contact with the base of the Keewatin series on Bleak Bay and on the Seine River, the Coutchiching schists plunge under the higher rocks in an almost vertical attitude. A little away from the line of contact, however, they become more inclined and the average dip for the first mile may be taken as about 75°; the average dip for the next mile and a half is about 45°; for the next mile and three-quarters, 30°; for the next mile and a quarter, 45°, and for the last three-quarters of a mile up to the line of the anticlinal axis, 75°. The total volume estimated from these angles is 23,760 feet, or 4·50 miles.

Synclinal axis.

Estimation of thickness.

First measurement.

The second or southerly dipping portion of the belt between the anticlinal and synclinal axes, or between Rat River and Kettle Falls is four miles and three-quarters in breadth, and presents a greater uniformity

Second measurement

of dip, the general average of which may be taken at about 75°; giving a thickness of 24,224 feet or 4·588 miles.

Third measurement.

In the third portion, or that between the synclinal axis at Kettle Falls to the southern limit of the belt against the gneiss and granite of Sand Point Lake, the dip again varies considerably. For the first two miles the average dip to the north is about 75°; for the next half mile, 50°; for the next mile and a half, 30°, and for the last two miles and three-quarters, 60°. Calculating in the same manner as before we find a thickness of 28,754 feet or 5·44 miles.

Diminution of thickness to the northward.

Thus the three independent measurements of the series shew a fairly satisfactory agreement, and they seem to be sufficient to establish its enormous thickness. So far as the figures are to be relied upon, they indicate that the series is thickest towards the south, and diminishes in volume northward.

Two other belts of Coutchiching.

Two other distinct, but stratigraphically connected, areas or belts of the Coutchiching series are known. Both of these have an anticlinal structure and dip under the Keewatin formations on either side of the axis.

Bear's Passage belt.

The first of these comprises the belt of mica schists (occasionally gneissic by addition of felspar) which extends from the neighborhood of the Bear's Passage across Rainy Lake in a W.S.W. direction to Coutchiching and thence down Rainy River. In the direction of its strike, the belt is traceable continuously for twenty-four miles, and it probably continues to the westward, under the post-glacial formations of the Rainy River, for a distance of at least sixteen miles. The breadth of the belt at the Bear's Passage and from that point to Open-water Narrows is about two miles and a quarter. Westward of Open-water Narrows the belt bifurcates around an area of gneiss, the more northerly spur running out to Gash Point, while the southerly or main spur keeps the general trend of the belt, and near Coutchiching is a little more than two miles wide.

Bosses of Laurentian gneiss in anticlinal axis.

The anticlinal axis of the belt is marked by a line, or series, of three distinct and well defined oval or elliptically shaped bosses of Laurentian gneiss. The Coutchiching schists dip away from these bosses in all directions, so that the general anticlinal structure of the belt is made up of three anticlinal domes. These three bosses of Laurentian gneiss cut the Coutchiching schists in the same manner as an irruptive granite and displace a very considerable proportion of the series in the middle of the belt. The first of these, which is well exposed at the Bear's Passage and the shore to the south-west of it, is three miles long and one mile and a quarter wide. The second, in the neighborhood of Open-water Narrows, is three and a quarter miles long, and one and a quarter miles wide. The third is over eight miles long, and two

miles and a half wide. In each case the long diameter of the boss coincides with the general trend of the schists composing the belt.

At the north end of the Bear's Passage the Coutchiching schists dip away from the Laurentian gneiss (or granite, for here it is very indistinctly foliated) at an angle of 40°. Across the strike, for a distance of a little over half a mile to the north-west, the angles of dip diminish and the rocks finally pass under the altered traps of the Keewatin inclined at an angle of 20°. All around the north-east end of the boss of gneiss, whose limit in this direction is the Bear's Passage, the schists dip away from it at comparatively low angles. At the south-east corner of Redgut Bay, east of the Bear's Passage, they gradually assume a constant N.N.E. strike and dip E.S.E. at angles varying from 60° to 75°; at which angles, both at the extreme south-east of Redgut Bay and on Swell Bay, one mile east of Bear's Passage, the Coutchiching rocks may be observed to pass under the Keewatin. The southern edge of the belt along the line of its contact with the Keewatin has already been sketched in the description of the distribution of the latter series. The Coutchiching rocks along this line appear to be the return of those which, on the south side of the lake, dip northward under the Seine River Keewatin belt, the two being continuous stratigraphically, and forming a synclinal trough in which that belt of the Keewatin lies sharply folded. The northern edge of the belt, between the north end of the Bear's Passage and the bay north of Open-water Narrows is only partially determined to be as mapped, the mapping being inferred from the known disposition of the mica schists inland on the north side of the Bear's Passage boss of Laurentian gneiss, and between the latter and the Open-water Narrows boss, where they constantly dip away from the gneiss and towards or under the Keewatin at angles nowhere greater than 60°. At the entrance to Rocky Islet Bay on the west side, the Coutchiching schists dip under the Keewatin at an angle of 60°, but along the shore from Back Point to Gash Point the dip is vertical or somewhat inverted. The rocks forming the belt have not been observed on the shore of the lake opposite Gash Point, north of Coutchiching, and the spur of the belt which terminates at Gash Point appears to have been cut off either by a fault or by an analogous displacement of the rocks by the Laurentian gneiss.

Coutchiching rocks passing under Keewatin.

Limits of Bear's Passage belt.

Perhaps the most remarkable feature of this belt is the smallness of the revealed thickness, as compared with the great thickness determined for the same series in the south part of the lake only a few miles distant. It is difficult to find sections across the belt where a satisfactory estimate of the thickness can be formed, on account of the interruption of the bosses of gneiss which occupy its central part along the anticlinal axis. The volume is, how-

Comparative smallness of volume.

ever, evidently small compared with that already described. The maximum measurable thickness is that revealed along the south shore from Rat-root Bay to near Coutchiching, where it is probably between 8000 and 9000 feet. This diminution in volume agrees with the fact already stated, as observed elsewhere, that the thickness diminished regularly towards the north. This thinning out may, however, be due to absorption in the magma from which crystallized the Laurentian gneisses and granites.

Excessive metamorphism at Contact with Laurentian.

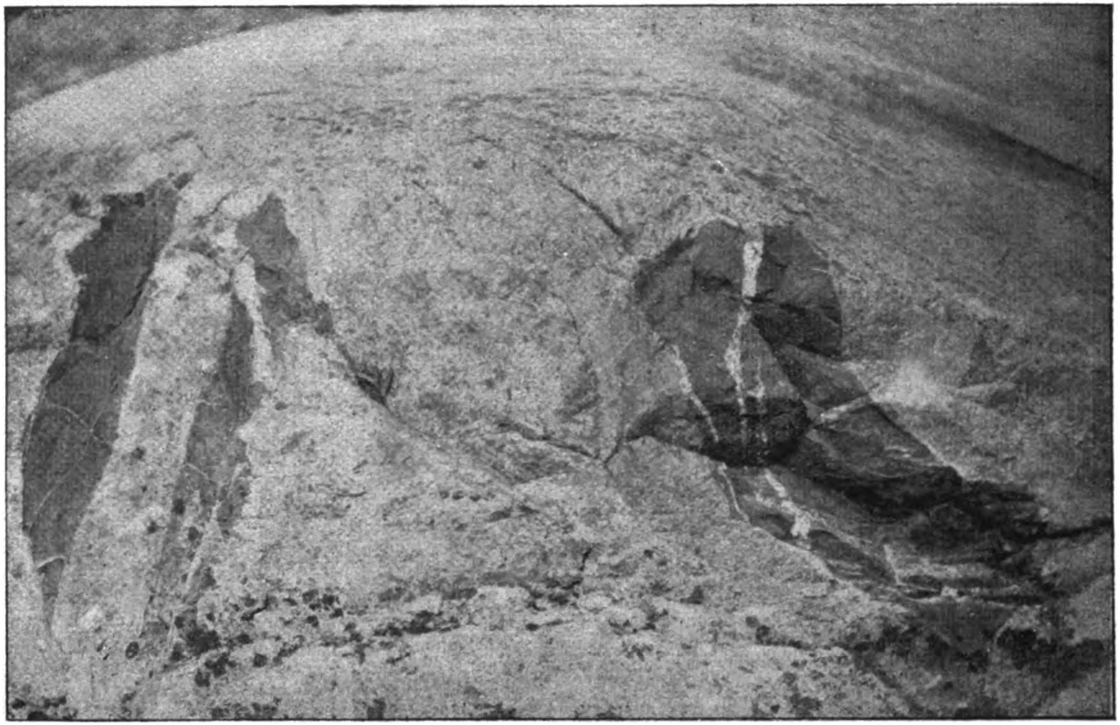
Those portions of the Coutchiching series which are in immediate contact with the bosses of Laurentian gneiss, are the most altered, and exhibit the strongly marked characters of contact metamorphism, being studded with nodule-like crystals of andalusite or staurolite. The rocks are, however, very much decomposed, and the metamorphic minerals have been much altered and removed by subsequent decay. The least altered portion of the series appears to be that which is seen on the south shore of the lake between Coutchiching and Rat-root Bay, where in places the schists have the character of bluish, somewhat micaceous quartzose slates.

Rice Bay area of Coutchiching.

The third area occupied by the Coutchiching series is that on the shores of Rice Bay. Here again the structure is that of a beautifully distinct anticline, the rocks dipping away at angles of 45° from the axis, and passing beneath the Keewatin rocks on either flank at the somewhat steeper angles of from 60° to 75°. The axis passes through the centre of the peninsula which separates the two arms of Rice Bay, but at the extremity of the peninsula, where it can be closely located, the base of the series is not revealed, and no estimate can be formed as to its full thickness at this place. A minimum thickness may be calculated from a revealed breadth across the strike of about one mile, the average dip being taken at about 60°. This gives a thickness of about 4,600 feet. The Laurentian gneiss appears in the axis of the anticline at the north-east end of the north arm of the bay. But the irruptive character of the gneiss precludes the assumption that the beds in contact with it are the proper base of the Coutchiching. The south-eastern flank of this anticline appears to form with the northern flank of the anticline of the second belt above described, a synclinal trough in which lie the Keewatin rocks exposed on the shores of Redgut Bay to the north of the Bear's Passage and on the shores of Grassy Portage and Rocky Islet bays. The connection of the two areas and their stratigraphical relationship is further seen in the band of Coutchiching rocks which surrounds the north-east end of the area of Keewatin rocks, and forms the rim in that direction of the basin or trough in which the latter lie.

Minimum thickness.

Stratigraphical relationship of different areas of Coutchiching rocks.



A. C. LAWSON, PHOTO, 1886. G. E. DESBARATS & SON, ENGRAVERS & PRINTERS, MONTREAL.

Angular inclusions of schist of Coutchiching series, inclosed in Laurentian gneiss, a few yards from the contact of the two, on island off south shore of Rainy Lake, three miles east of Coutchiching.

Relations of the Coutchiching Series to the Keewatin and Laurentian.

Without being able to conclusively prove it, there appears to be much presumptive evidence in the facts cited to shew that the present eminently crystalline state of the Coutchiching series is the result of the metamorphism of strata which were originally in large part ordinary quartzose sediment, although part may possibly have been acid volcanic rocks, such as quartz-porphyries or felsites. In many parts of the series garnets abound, and if the rocks were carefully examined other metamorphic minerals would doubtless be found. That percolating siliceous solutions were active agencies in effecting the metamorphism of these strata, is proved by the fact that in many places, particularly on the north side of Saginaw Bay and east of Brulé Narrows, the partings between the beds have served as fissures for the deposition of vein quartz. This vein quartz is very abundant in lenses or lens-like sheets, and is clearly a secondary product in the rock. The same watery solutions which deposited the quartz in these lenses in the more open portions of the formation, must have saturated the rock throughout, and given rise, probably, to much of the quartz and felspar in it. Only in one instance has hornblende been observed throughout the whole series. There are no intercalations of basic volcanic rocks, and none that can now be distinctly recognized as acid volcanic rocks. There are no limestones or dolomites in the series, nor have any conglomerates been observed.

The Coutchiching metamorphic series.

Vein quartz between strata.

The advent of the time of the formation of the Keewatin rocks was the inauguration of a period of intense volcanic activity. Prior to that there is no certain record of volcanic action; while a very large proportion of the total volume of the Keewatin is made up of volcanic rocks, such as diabase and quartz-porphyry, with their tuffs and agglomerates.

Period of volcanic activity following quiescence of Coutchiching.

Such a change in the conditions of rock formation does not in itself necessarily imply any great lapse of time between the cessation of the accumulation of the Coutchiching and the deposition of the first rocks of the Keewatin. That there has been a certain interval, however, during which erosion has taken place is indicated by the conglomerate at the base of the Keewatin on Seine River and Rat-root Bay. If the question of the conformity of the two series is to be decided merely by the parallelism of the structural planes in the vicinity of the contact, the two series should be described as conformable. But if the question is considered more broadly, and the term unconformity is to be regarded as expressive of a geological break, or profound change in the conditions of rock formation, then the two series are unquestionably unconformable.

Nature of break between Coutchiching and Keewatin.

Relations of Coutchiching to Laurentian.

With regard to the relationship of the Coutchiching series to the underlying Laurentian, little need be added to what has already been said. Wherever the contact of the two is observable that contact is igneous and more or less brecciated, the conditions being precisely the same as those which prevail at the contact of the Keewatin and Laurentian at places where the Coutchiching rocks do not intervene. The contact is well seen on a small island just three miles east of Coutchiching. The north half of the island is occupied by Laurentian gneiss, which is presumably continuous with the area of the rock so well exposed on the islands between Open-water Narrows and the vicinity of Gash Point. The south half of the island is occupied by the schists of the Coutchiching series. The line of contact runs across the island in a direction parallel to the strike of the schists. Apophyses from the gneiss cut the Coutchiching schists transversely, and these are distinctly foliated; while fragments of the schists of irregular angular contour, which have very evidently been detached from the main mass of the Coutchiching, are found imbedded in the gneiss at a few yards from the contact. Plate I. shews the nature of these inclusions, as well as the distinct foliation of the gneiss in which they are imbedded, close to the contact. The same phenomena are very apparent at many places on the islands where the contact of the Coutchiching is mapped between Open-water Narrows and Gash Point, and at many places where the contact is not seen, large masses and bands of the Coutchiching schists may be seen imbedded in the gneiss, the schist, where in large bands, being more or less shattered and penetrated in all its fissures by the gneiss which retains its foliation usually parallel to the walls of the fissure as shewn in Plate II. representing a contact on one of the islands between Back Point and Gash Point. The exposures in the vicinity of Open-water Narrows and Bear's Passage afford good instances of the intrusion of the gneiss through the schists, although here the former is more granitoid than it is farther west on the islands in the neighborhood of Gash Point. Plate III. shews the contact of the Laurentian gneiss and the Coutchiching mica schists at the south-east part of Redgut Bay, where the gneiss cuts the schists sharply and the latter abut upon it obliquely.

Irruptive character of contact.

Penetration of schists by gneiss.

Contact on Redgut Bay.

The rocks of granitic composition, which cut the Coutchiching series on the shores and islands of Rainy Lake between Brulé Narrows and Kettle Falls, are in some places distinctly foliated and gneissic, while in others they are quite undifferentiated or granitoid in structure. The same is true of the Laurentian rocks which break through the same series on Nameukan Lake. In both cases the gneiss or granite cuts the schists in the most irregular fashion and numerous detached portions of the latter are imbedded in it. The same conditions prevail at the contact across the north end of Sand Point Lake.

Sporadic intrusions of granite and gneiss.

A. C. LAWSON, PHOTO., 1884. G. E. DESBARATS & SON, ENGRAVERS & PRINTERS, MONTREAL.

Contact of Laurentian gneiss and schists of Coutchiching series, Redgut Bay, two miles and a half east of Grassy Portage, Rainy Lake. The schists (on the right) abut obliquely upon the gneiss, which appears to cut them as an irruptive mass.

Coutchiching Series.

The rocks of the Coutchiching series deserve a much more thorough microscopic investigation than I have had an opportunity of giving them. A close comparison of their detailed structure with that of the Laurentian gneisses, which in this region appear to the writer to be beyond question irruptive, would, he is convinced from a consideration of their field conditions, throw much light upon the vexed question of the distinction between gneisses (?) which are truly altered sediments, and gneisses which are nothing more than foliated granites. Need of more extensive study

The leading macroscopic characters of the rocks of the series have already been given, and it only remains to add a description of the microscopic character of the few typical specimens which have been examined, in order to put on record all that is up to the present known of these rocks.

Mica Schists and Granulitic Gneisses.

Near the Coutchiching Rapids the rocks are typical mica schists of the series. They are dark, fine-grained slaty rocks made up essentially of quartz and biotite. A thin section (690) of a specimen from the shore of the lake to the east of the rapids shows it to be an aggregate or mosaic of rounded or sub-angular grains of quartz of a generally uniform size. The quartz is characterized by a more or less undulatory extinction, suggestive of unequal tension. Biotite is in irregularly shaped plates lying in parallel position, determining the schistosity of the rock. A little muscovite accompanies the biotite, and epidote in yellowish to colorless crystals, and in aggregates of such crystals, is sparingly present. Limonite is generally distributed in large and small grains. Apatite also is an accessory constituent. Coutchiching rapids.

On the south side of Knuckle Island, about a mile and a half east of Open-water Narrows, the mica schist is observable in immediate contact with the southern margin of the Open-water Narrows area or boss of Laurentian gneiss. The line of contact of the gneiss and mica schists is parallel to the shore of the island, and close to the waters edge, so that the accessible contact zone of schists is a narrow one. The schist is a fine-grained, light grey, fissile rock, with lumpy or nodular cleavage surface, due to the presence in the schist of large rounded or stoutly spindle-shaped bodies, (occasionally square or rectangular in outline) which give it a gnarled or knotted appearance. The rock is rather soft and fissile, due to decomposition under weathering influences. Under the microscope, (1560) the mass of the rock is seen to be a fine-grained aggregate of granulitic quartz and brown biotite in small plates all arranged parallel. In this, as base, are imbedded large, oblong Contact zone.

plates of muscovite with parallel basal boundaries, but ragged and shred-like at the ends. These plates of muscovite are congregated together in nests with some of the base of the schist, in a modified form, as interstitial cement. This cement differs from the rest of the schist in having more biotite and less quartz in its composition. Besides these nests of large plates of muscovite, there are larger, light-colored areas of oval outline, but of irregular boundaries, which appear to have been probably occupied by crystals of andalusite, or some allied mineral as a product of contact metamorphism. In the present altered condition of the rock the original mineral is replaced by a grey mass of minute particles of muscovite and kaolin, which polarize as an aggregate. The quartz of the schists is seen occasionally to enclose minute shreds of biotite. The total absence of felspar in a rock which has undergone contact metamorphism at the contact with a granitic mass is an interesting fact. It is in harmony with Rosenbusch's observations on the contact zone of Barr-Andlau.*

Absence of felspar in altered rock at contact.

Rock from top of series.

A specimen from the top of the series near the contact with the Keewatin at the west end of Red-pine island is a dark, grey, fine-grained, micaceous schist. Under the microscope, (1436) it appears as a fine-grained quartzite, made up mostly of grains of quartz with a little felspar and a good deal of brown biotite. The quartz grains appear in section as a mosaic, but present a distinctly rounded or granulitic aspect. There are, however, areas in which mosaics of coarser texture appear with the grains more interlocking. These are probably secondary. There are also occasional larger broken pieces of plagioclase and quartz, which shew a partial rounding of the contour, as if by abrasion. Calcite and a little muscovite are also present as secondary minerals.

South shore Rainy Lake.

On the south shore of Rainy Lake near Coutchiching Rapids there is in association with the mica schists an iron grey, micaceous gneiss differing from the former only in the possession of a felspathic constituent. It might perhaps be rather called a felspathic mica schist than a gneiss. In thin section (690 b) it is seen to be composed of quartz, orthoclase, plagioclase, biotite and muscovite. A more or less distinct rounded or granulitic appearance is presented by the orthoclase, though not by the plagioclase. The quartz contains inclusions of apatite in characteristic jointed needles, besides opaque minutely granular bodies.

Bleak Bay.

The rocks on the south side of Bleak Bay are fine-grained, grey gneisses or felspathic mica schists. A specimen (53) in thin section, cut parallel to the schist planes, appears as a more or less granulitic

* Die Steiger Schiefer und ihre Contactzone and en Graniten von Barr-Andlau, Strassburg, 1877.

mosaic of quartz, orthoclase and plagioclase, with an abundance of fresh biotite, mostly arranged in parallel position. Both quartz and felspar contain numerous liquid inclusions, some with bubbles, together with minute microlites. A number of opaque grains of uncertain character are also present. A similar rock, from one of the islands in this part of the lake, in which the section (55) is cut perpendicular to the schist planes, resembles the last closely. The orthoclase is cloudy, while the plagioclase is quite fresh. The quartz contains liquid inclusions with moving bubbles, and hair-like needles of rutile, besides oval grains of apatite. There is a well marked tendency to granulitic structure in the quartz and orthoclase, while the plagioclase is usually in irregular shaped grains. The biotite is in plates of various thickness lying in parallel position.

Another specimen from the south side of Bleak Bay resembles (53). It is very quartzose, and the disposition of the biotite is such as to give it a spangled appearance. Under the microscope, the rock has a strongly marked granulitic aspect, the grains of quartz and felspar having a prevailingly rounded shape. The grains are of varying size. The quartz preponderates very much over the felspar and is full of liquid inclusions arranged mostly in streams. Fresh, brown biotite is distributed throughout the section in small shreds and large plates all in parallel position.

Rocks near Cranberry Bay.

A specimen from the south shore of the lake between Cranberry Bay and Brulé Narrows, resembles the last in general appearance. In thin section (1239) it is seen to be made up of quartz, plagioclase, biotite, muscovite and garnet. The granulitic or rounded character of the constituent grains is confined to the quartz, part of which, however, is also in elongated, irregular lenses. The plagioclase occurs in grains of quite irregular shape, adapted to the contours of adjoining grains, in other words, is granular in the sense in which Rosenbusch defines the word. The biotite is much more abundant than the muscovite and occurs in large plates. Both micas are in parallel position throughout the section. A few garnets of a purplish grey color occur, some of which are the largest individuals of all the minerals in the rock. These are of irregularly rounded shape, and sometimes enclose portions of the base of the rock.

Lob-stick Island.

On the east side of Lobstick Island the series is represented by a dark, pepper-and-salt grey, glistening schist of very fine-grain. Under the microscope (680) it is seen to be composed of quartz, orthoclase, plagioclase and biotite, with a little hornblende. The biotite is very abundant in irregular shaped plates, lying in parallel position. The orthoclase exhibits a zonal structure, the outer portion being of different optical orientation from the inner perfectly shaped crystal which

forms the nucleus of the irregularly shaped grain. The same structure is less commonly exhibited by the plagioclase. In many of the felspars, ocherous or dusty matter, together with minutely granular or granulitic matter, is congregated in more or less spherical bunches in the centre of the grain. Otherwise, the felspars are fresh and glassy. The hornblende is usually in elongated, but irregularly shaped grains. The structure is for the most part granular.

Rocks of Rice Bay area of Coutchiching.

The rocks of the Rice Bay area of the Coutchiching series differ somewhat from those of the same series farther south. They are as before all very quartzose and fall into two varieties, those containing felspar and those free from it. In the latter, which are probably the more prevalent, the rock is either made up of a very schistose interleaving of thick layers of quartz and thin films of dark green scaly chlorite, apparently an alteration production of biotite; or is composed of a similar but less even interleaving of quartz and muscovite, the latter being more abundant than the chlorite in the first case. In the felspathic variety, both biotite and muscovite are usually present, the biotite predominating, and the rock assumes the form of a gneiss of peculiar character, in which the quartz is disposed in lenses usually from one-eighth to one-quarter of an inch in diameter, and from one thirty-second to one sixteenth of an inch thick at the middle. If not in lenses the quartz is in very distinct sheets often one or two inches across, and one sixteenth to one eighth of an inch thick. These sheets taper towards their periphery and are, indeed, also much flattened lenses of great diameter. In these rocks orthoclase occurs sometimes in large crystals from half an inch to an inch across, with their greatest diameter parallel to the schist plane, and the plane of composition of the Carlsbad twins inclined at an angle of about 45° to the same. These crystals of orthoclase usually have long tails as in the felspars of augen gneiss. Whether the habitus of the quartz and orthoclase are the result of pressure analogous to that described in the Saxon granulites by Lehmann, or whether they partake of the nature of vein minerals due to the percolation of heated solutions, is a question which can only be decided by a much more careful microscopic study of the rocks than I have had an opportunity of giving them. Apart from these augen-like orthoclases, which are only of occasional occurrence along certain lines, particularly in the rocks on the west side of the narrows of the north arm of Rice Bay, there is a considerable proportion of felspar associated with the quartz throughout the rock. The schists, or gneisses, in which the augen-like felspars were observed, are in proximity to the very coarse mica-syenite or syenite gneiss on the south-east side of Hopkins Bay which appears to be of irruptive origin. Only a few characteristic specimens of these rocks have been examined microscopically.

Macroscopic characters.

At the entrance to Rice Bay, on the west side, the series is represented by a fine-grained, evenly laminated grey gneiss. Microscopically (1506) it appears as a granulitic aggregate of quartz, orthoclase, plagioclase and biotite, with some muscovite and epidote. As a rule, the granulitic or rounded character of the quartz and felspar is very marked. The quartz contains liquid inclusions. All the mica plates are in parallel position. Entrance to Rice Bay.

On the west side of the Narrows of the north arm of Rice Bay, a rock occurs whose macroscopic characters have been described on the last page. Under the microscope, (1519 A) it appears as an eminently granulitic aggregate of quartz, orthoclase, microcline, plagioclase and biotite, with some muscovite and epidote. The granulitic or rounded character of the grains is, however, characteristic only of the quartz and orthoclase, while the plagioclase often presents irregular or granular shapes. The felspars are all quite fresh. Rice Bay narrows.

A specimen from the north shore of the east arm of Rice Bay, is a schist made up of muscovite and quartz. In thin section (67) the quartz appears in areas of granulitic grains surrounded by muscovite which is very abundant, both in broad plates and in compact aggregates. The quartz is full of colorless microlites. The plates of muscovite are in parallel position. East arm of Rice Bay.

A specimen from the north end of the north arm of Rice Bay is a schist composed of alternate thick layers of quartz and thin films of green biotite or biotite altered to chlorite. Under the microscope (66) the quartz is granulitic, and contains liquid inclusions and microlites. North arm of Rice Bay.

On an island in Rainy River, a little over four miles above Manitou Rapid, there is an outcrop of a rock which has provisionally been classed with the Coutchiching, although its isolated character renders its stratigraphical relations a matter of conjecture. It has the aspect of a very fine-grained, grey gneiss of even lamination, but microscopically (1604) it appears to be little more than a micaceous sandstone or quartzite. It is made up mostly of quartz, with a little plagioclase in grains of varying size, partly rounded and partly angular. It is evidently a clastic rock, the chief alteration which it has undergone being the development of secondary quartz in mosaics and of muscovite and brown biotite in small irregular plates lying in parallel position. The rock is scarcely schistose. The rounded shape of the constituent grains of quartz appears to be due to water-wearing action in an original sand. There is a good deal of cloudy, kaolin-like material scattered through the section. Coutchiching on Rainy River.

A.—Laurentian.

It will be convenient in describing the Laurentian of the region under consideration, to deal with each area separately, dwelling particularly only on that which has been most closely studied, viz.: the Stanjikoming area.

Stanjikoming area

The limits of this Laurentian area have been already described and are shewn on the map of the region which is being prepared. It has a north and south diameter of thirty-two miles, and its greatest diameter is an east and west direction, from Clear-water Lake to the east end of Redgut Bay, is about forty-six miles.

Dimensions

Area separable into two parts.

The area is naturally separable into two distinct parts, according to the character of the rocks which compose them, viz., (1) an inner nucleus, and (2) a broad peripheral zone. The distinction between these is very clearly and sharply defined in the northern half of the area, but much less so in the southern half. The inner nucleus is composed essentially of a biotite-granite gneiss of medium texture and grey color, which is very quartzose and distinctly foliated. The rocks of the peripheral zone are more basic than those of the inner nucleus. The prevailing habitus is that of a syenite, or hornblende-granite, quartz being either absent or only sparingly present. The color is either grey or reddish; the texture is coarse-grained and the gneissic foliation very much less pronounced than it is in the biotite gneisses of the inner nucleus.

Line of demarkation between peripheral zone and inner nucleus.

From the west end of the North-west Bay the line of demarkation between the inner nucleus and the outer zone of hornblende-syenite gneiss, with its local facies of hornblende-granite, and even biotite-granite, gneiss, has been traced very satisfactorily as mapped, around in an irregular crescent, concave to the south, to Redgut Bay. From Lake Despair, across the Despair River and the various arms of Jack-fish Lake, through Loon Lake, across the Manitou River above the Devil's Cascade, and thence across Vane Lake and Capt. Cuttle Lake to Black Sturgeon Lake and Crow Rock Inlet, the line is very sharp, and can be located at all of these various points of intersection very closely, there being a sudden change from one rock to the other. This line is rudely parallel to the line of contact previously sketched between the Keewatin and Laurentian. Between these two roughly parallel lines the zone of syenitic gneisses has a breadth which varies from three to to six or seven miles. That the whole of this breadth is occupied by the same kind of rocks is established by the examination of the well bared shores of the half dozen or more canoe routes, which traverse it at intervals sufficiently close to afford the necessary data for mapping.

At the two ends or horns of this crescent-like zone it appears to become confused with the biotite gneisses of the inner nucleus, and to blend with them in a manner which seems only explicable on the supposition that the two rocks were both in a more or less plastic or fused state at the same time. This lack of sharp distinction between the two kinds of rock begins on the west side on Lake Despair and becomes more and more apparent as we endeavor to trace the syenite gneiss across the end of North-west Bay to Half-way Inlet. A band of these syenite gneisses certainly crosses the North-west Bay in the direction indicated, such direction being coincident with the strike of the evenly foliated biotite gneisses. But in this band are portions which are scarcely distinguishable from the ordinary biotite gneisses, except, perhaps, that they are rather coarse-textured, and which do not appear to be inclusions, but pass into the syenitic phase of the rock by gradations. In the adjacent biotite gneiss, also, which occupies the greater portion of the shores of North-west Bay, there are local developments of a syenitic facies. These are intimately associated with what appear to be included masses and bands of hornblende schist, or massive dioritic rock, in the more acid biotite gneiss, and it would appear in these cases that the coarse syenite gneiss, whether it be mica-syenite or hornblende-syenite, has resulted from the fusion and intermixture of the more acid with the more basic rock. The first occurrence of this coarse syenite gneiss observed in going up the bay is on the south shore opposite Shelter Island, where it has the facies of a porphyritic mica-syenite with frequently a little quartz. At all the available exposures on the shores of Half-way Inlet, this gneiss appears to be the prevailing rock, from a point a quarter of a mile north of Cliff Narrows to the bottom of the inlet. It also appears on the S.E. shores of the terminal expansion of the North-west Bay and occupies probably a mile and a half of the shore. It occurs also on the north, or north-west shore of this same expansion of the bay, opposite Gusty Point. Here, however, as at other places, it is much mixed with the ordinary biotite gneiss, so that the relationship that exists between the two is difficult to make out. In some places it appears to cut the latter as an intrusion through it, but this appearance only extends to the sudden and boss-like presence of the syenite in the midst of biotite gneiss, and contacts where the relationship can be satisfactorily studied, are difficult to find.

Breadth of zone.

Local blending of two kinds of rock.

Gneisses on shores of North-west Bay.

In its continuation to the S.E. the band appears to thin out to a narrow width between Half-way Inlet and the west shore of Rainy Lake, where nothing but biotite gneisses are found, except at a point three-quarters of a mile N.W. of Standing-stone Point, where a small patch of syenite was observed; and some on the latter point itself.

Continuation of zone of syenite gneiss on Rainy River.

It seems probable that the zone of syenite gneiss which thus begins, at the west end of the North-west Bay, to become confused and mixed with the biotite gneiss, is continued in the area of hornblende syenite gneiss, which is exposed on Rainy River between six and seven miles above the Manitou Rapid, and also in the area of coarse mica-syenite gneiss which is exposed on Rainy River at Fort Frances and thence northward for about six miles on the west side of the lake to Stanjikoming Bay. The small area of hornblende and mica-syenite gneiss observable on the south-east side of Hopkins Bay seems to serve as a link of connection between the last and the first described crescent-like zone at its eastern extremity on Redgut Bay. On the Big Canoe River route, the syenite gneiss occupies the whole of the breadth between the inner nucleus of biotite gneiss and the base of the Keewatin. South-eastward of this, however, the zone of these rocks appears to diminish rapidly in breadth, and on Black Sturgeon Lake and Crow Rock Inlet is little more than a mile wide. In this interval, moreover, the rocks composing it are no longer in direct contact with the Keewatin, for the exposures on Big and Little Saw-bill lakes, Porter Inlet, and the north end of Redgut Bay, shew that an area of ordinary quartzose, biotite gneiss lies between the Keewatin and the zone of syenitic gneiss. The latter seems to taper to a point on Redgut Bay, and where it does so, it appears in places to be intimately mixed with the biotite gneiss and appears further, in certain cases which have been examined carefully, on the north side of the bay opposite the Indian village, to result from the fusion of the biotite gneiss with certain included bands or masses of hornblende schist and diorite, which will be alluded to more particularly in the discussion of inclusions in gneisses.

On Big Canoe River route.

Distribution of two gneisses north of Redgut Bay.

Relationship of structural planes of two gneisses at contact.

Above the Devil's Cascade, on the Manitou route, the biotite gneiss may be seen very clearly dipping under the syenite gneiss at an angle of about 60°. On the south-east side of Loon Lake the two rocks are in the same relative attitude, the angle of dip varying from 45° to 60°. At the lower end of Loon Lake, and across Jack-fish Lake, the dip of the biotite gneiss is much less regular, being sometimes away from and sometimes towards the syenite gneiss, the former being the prevailing dip on Jack-fish Lake and on Reserve River. On Vane Lake the planes of foliation of the gneiss are not sufficiently regular to afford an indication of the dip. At the contact here of the biotite gneiss with the hornblende-syenite gneiss, the former is traversed by dykes of granite, while the latter is not. At the contact on Captain Cuttle Lake, no very exact line of demarkation could be detected, but rather a passage from the biotite-granite gneiss, through hornblende-granite gneiss to the syenite gneiss.

The only portion of the zone where the rocks vary so much from their general character as to pass completely from the syenitic facies, and become prominently quartzose and granitic, is at its extreme east end. On the shores of the west arm of Jack-fish Lake, the rocks are somewhat quartzose, and the quartz becomes more abundant on Clear-water Lake, where the rock is a coarse-granite, foliated in some places, and scarcely at all, in others.

Variation from normal character.

The biotite gneisses of the inner nucleus of the Stanjikoming area of Laurentian rocks, are, as regards their field characters, chiefly remarkable for the constancy of their composition and general aspect, the uniform regularity of their foliation, the regular dip of such planes of foliation, generally at angles of from 45° to 60°, and the ease with which the strike of their edges can be traced in curves which, in one notable instance at least, close upon themselves in concentric circles. The gneiss is characterized, too, by holding included fragments of foreign rock, which resemble the rocks of the Keewatin and Coutchiching series. These inclusions will be considered more in detail in the next section. The contact with the geologically higher series of Coutchiching and Keewatin rocks is always of a more or less distinctly brecciated character, the gneiss sending apophyses into the schists, and holding imbedded in it detached angular fragments of them. The geologically colored map, taken with the detailed descriptions of typical specimens of the rocks, renders a lengthy account of the geological features unnecessary. Attention may, however, be directed particularly to the structure of the rocks of this portion of the area. The plotting of the observed strikes and dips shows that if we follow the strike of the planes of foliation from the Devil's Cascade southward, it curves gradually to the south-west and west on the shores and islands of Manitou Sound and the bays to the west of it; then north-west along the shores of the North-west Bay and Foot Print Lake, north to north-east through Jack-fish and Loon Lakes, and finally south-east at the south-east part of Loon Lake where the rocks trend directly towards the starting point at the Devil's Cascade, joining in a complete circle. This circular trend of the strike of the planes of foliation of the gneiss is constant in a zone which has a considerable breadth measured on the radii of the circles or in a direction transeverse to the strike. The breadth of the zone bears no relationship to the angle of dip, being no greater where the dip is low than where it is high. Thus from the north side of Ash Bay to Ami Point, the rocks have a constant dip to the south-eastward of from 30° to 45°, and the breadth of the zone is much the same as at the opposite side of the circuit where, on Loon Lake and Jack-fish Lake, the dip is at a much higher angle. The angle of dip is also high along the North-west Bay. The concentric circles thus formed by the inter-

Biotite gneisses of inner nucleus.

Concentric structure of foliation.

section of the planes of foliation with the horizontal plane of the present surface have their centre in a point which appears to lie in the north arm of Ash Bay, the rocks in that vicinity being at extremely low angles, almost flat in some cases, and the strike consequently difficult to trace. The dip is away from this centre all the way around, so that the structure is the same as that which would be revealed by a section across a low cone or dome laminated concentrically to its surface. The simplest explanation that suggests itself to account for the structure, is that of an upheaving force acting on a plastic mass, such force acting with greatest intensity in the vertical line which would correspond to the axis of the cone or dome. This would correspond to an anticlinal dome in ordinary bedded formations. With this difference, however, that in the latter the structural planes existed as planes of bedding prior to the application of the force which bulged it into a dome, whereas in the case of this Laurentian gneiss, all the evidence goes to show that the structural planes are the result of such upheaval and a differentiation, from the homogeneous character of the rock, produced by the deformation incident to it.

Focus of concentric structure.

Synclinal and anticlinal structure.

South of a line drawn from Ami Point to the entrance to the North-west Bay, between Hay-marsh and Woodchuck Islands, the dip is very suddenly reversed and we have what appears to be a synclinal axis, the strike on either side of the line diverging to the eastward. A parallel line four miles to the southward, drawn from Frog Portage to the neighborhood of Standing-stone Point, appears to be the corresponding anticlinal axis, for on the south side of this, the dip is again to the south or south-east.

Sporadic intrusions of granite.

Between these two lines, the dip is constantly to the north, and the rocks lying within them are much traversed by local or sporadic intrusions of red granite accompanied by pegmatitic veins. Along the line of the anticlinal axis just mentioned, the biotite gneisses are observed locally to give way to hornblende granite and syenite gneisses. To the south of the line a considerable number of observations have been made as to the strike and dip, but no general statement as to the structure can be deduced from them beyond the fact that the dip is prevailingly south-eastward or eastward on the west side of the lake where the strike curves around to a north and south direction. In this part of the area, inclusions of rock fragments resembling the formations of the Coutchiching series are more abundant in the gneiss than farther north. Indeed in some places, notably between Blaze Point and Frog Portage, the gneiss appears to be quite composite in character, as if made up of shattered fragments of such rocks as occur in the Coutchiching series which had become immersed in a felspathic magma, partially fused and drawn out into lenticular bands. Some

Composite character of gneiss locally.

phases of this variety of the gneiss present a remarkably evenly rib-banded aspect due to alternations of sheets of dark, fine-grained, very micaceous rock, with others of light grey color, of coarser grain and mostly felspathic, with little or no mica.

Bosses of Laurentian gneiss between Bear's Passage and Coutchiching.

The three small bosses of biotite gneiss that lie in the axis of the anticlinal fold of Coutchiching rocks which stretches from the Bear's Passage to Coutchiching have already been alluded to at sufficient length (p. 102). It only remains to be noticed that the gneiss of the most westerly of the three exhibits the most pronounced, and that of the most easterly the least pronounced foliation, or is most granitoid. In all three the evidence of their protrusion through the Coutchiching rocks is most clear, and also that the protrusion has been one of slow upheaval of a magma which must have been very thickly viscid, or tough and coherent, rather than fluid. For the gneiss has not simply filled a dyke-like fissure in the Coutchiching schists, but has displaced the latter in such a way that the strata have everywhere accommodated themselves to the shape of the protruded boss, i.e., the strike conforms to the shape of the boss, and runs around it, while the dip is constantly away from it. The dykes that emanated from the gneiss and penetrate the schists at the contact are of a local character, and do not extend far within the schists, being originally rather of the nature of a plastic mass forced into fissures and crevices by great pressure, than fluids filling cracks in the crust like regular dykes.

Sabaskong Laurentian area.

The rocks of the Sabaskong Laurentian area, so far as they are known, on the Kishkutena route, Sabaskong Bay, and the shores and islands of the south part of the lake, are mostly quartzose gneisses. An exception to this general rule is found in a mass of hornblende-syenite gneiss, of very coarse texture and very indistinct foliation, which occupies about two miles of the south-east shore of Lake of the Woods, beginning at a point one mile north of the 49th parallel. A patch of the same rock also occurs on the extremity of Pork Point. All the other rocks are either biotite-granite gneiss or hornblende-granite gneiss, the latter being usually only a local facies of the former. Thus the rocks of Sabaskong Bay, as a whole, resemble very closely those of the inner nucleus of biotite gneiss of the Stanjikoming area, but on the islands at the mouth of the bay, on the south shore where it opens out to the lake, the proportion of the quartz is less, hornblende replaces a part of the biotite, and finally the rock passes into a hornblende-granite-gneiss in which there is no mica. At the east end of the bay, the proportion of mica becomes less, and that of quartz increases, and the whole aspect of the rock is more granitoid and perhaps coarser grained. This increases along the Kishkutena route, till on Kishkutena Lake the rock is a very quartzose, coarse-grained,

Variation in character of rocks.

reddish granite, with a foliation only occasionally developed, but still geologically the same as the evenly foliated gneisses of the western and middle portions of Sabaskong Bay. The strike of the planes of foliation of these gneisses exhibits a marked tendency to a disposition in concentric circles similar to that observed on Rainy Lake. The gneisses both here and on the south-east shore of the lake towards the mouth of Rainy River are often charged with inclusions of hornblende schist and dioritic or amphibolitic rock. In Sabaskong Bay their foreign and included character is much more apparent than in the gneiss south of the mouth of Little Grassy River, where the schist and gneiss are either confusedly mixed, or appear in remarkably even inter-bandings, due, doubtless, to pressure deformation, such as that discussed by Teall,* with this difference, that, whereas, Teall regards the more basic bands as the squeezing or pulling out into sheets of the more basic early secretions from the magma, the evidence here points to their having been fragments detached from the once overlying Keewatin series, or pipes of volcanic rocks that filled vents in the floor upon which the Keewatin was deposited, and which by fusion and recrystallization gave rise to the Laurentian gneiss. Even where they are most evenly banded, there is occasional evidence of the gneiss having been the matrix, since it traverses the schists locally transversely to the strike. Many of these inter-bandings appear, too, as I have before stated, to have been produced by the penetration of the gneiss in a plastic condition along fissures which are coincident with the cleavage planes of the schist, the latter having been parted on the large scale in a manner similar to that shewn in Plate VI for a comparatively small inclusion.

Inclusions of foreign fragments.

Turtle Lake Laurentian area.

In the Turtle Lake Laurentian area, so far as it comes within the limits of the region examined, the greater part of the gneisses are quartzose, biotite gneisses, similar to those of Rainy Lake and Sabaskong Bay. Going northward from Rainy Lake to Manitou Lake, by way of the Otukamamoan route, all the shores of the lakes as far as the outlet of Kinojé Lake are composed of this rock. Between this point and the Manitou Lake, however, we come upon rocks of the character of hornblende-granite and syenite gneiss of much less distinct foliation and coarser texture. These are very similar in character to those of the peripheral zone of the Stanjikoming area, and occupy a similar position relatively to the biotite gneisses and to the Keewatin series. These hornblende-granite and syenite gneisses are well exposed on all the shores of Kionjé, Kahwawiagamak, Memekwesi (west end), Downgrade, Smooth-rock, and Windigons Lakes. All the Laurentian rocks observed on the shores of lakes and rivers between the Otukamamoan

Zone of syenitic gneiss similar to that of Stanjikoming area.

* On the origin of certain banded gneisses, Geol. Mag., Nov., 1887.

route and Big Turtle River, and on Big Turtle River itself, to a point one mile north of Jones Lake, are quartzose, biotite gneisses. At the point above Jones Lake just mentioned, however, we come upon coarse, reddish, hornblende-syenite gneiss. This is probably geologically the same with the hornblende-syenite and granite gneiss observed at the north end of the Otukamamoan route, and if so, they would appear to form a zone quite as extensive as the peripheral zone of the Stanjikoming area.

Lake Harris Laurentian area.

The Lake Harris Laurentian area on the northern limits of the region mapped, has only been partially examined. The small portion of it which comes within the limits of the Rainy Lake sheet appears to be continuous with the Laurentian known to occupy the shores of the middle and eastern parts of Deer Lake and which, according to Bell,* also occupies the shores of Hugh Osbourne's Lake, and of lakes Rowan, Hill and Lawrence. If this be so, then the Lake Harris area is an immense pear-shaped area of Laurentian rocks completely encircled by the rocks of the Keewatin series, and so quite analogous to the Obabicon, Sabaskong, and Stanjikoming areas. From Dr. Bell's account of the distribution of the (Huronian ?) Keewatin on Wabigoon and Eagle Lakes, and our own knowledge of the distribution of the Keewatin on the Manitou route and thence continuously by way of Pipe-stone Lake, Crow Lake and White-fish Lake to the west end of Deer Lake, there appears to be no doubt but that the area is completely encircled, as stated, by these rocks.

Encircled by Keewatin schists.

The interior of the area has not yet, however, been examined and all that can be said at present is that it is very probably entirely occupied by Laurentian gneiss. The greatest length of the area in a N.E. and S.W. direction is forty-five miles, and its greatest width, from Lake Harris across to near the outlet of Deer Lake, is about twenty-five miles.

Lake Harris.

On Lake Harris the gneiss is coarse and granitoid with very indistinct foliation, or none at all. Hornblende-granite and biotite-granite both prevail, the former, however, being probably more abundant than the latter. Both kinds are simply different facies of the same geological mass. No varieties were here observed which are entirely devoid of quartz.

Bluff Lake.

On Bluff Lake, however, the Laurentian rocks in the vicinity of the contact with the Keewatin are very basic, and have the facies of a uralitic gabbro. Towards the north this passes into a hornblende-syenite gneiss and then into a hornblende-granite gneiss, the rocks at the north end of the lake being distinctly quartzose.

* Geological map of the Lake of the Woods and adjacent country, 1881.

PETROGRAPHY OF THE LAURENTIAN ROCKS.

Hornblende-Granite and Hornblende-Syenite Gneiss.

Different facies of same rock mass.

The hornblende-granites, foliated and non-foliated, are not separable, geologically, in the Rainy Lake region, from the hornblende-syenites. In the former, the quartz is never, as a rule, very abundant; and in the same geological mass, specimens may be taken which, regarded in themselves, would be classed as hornblende-granites, while others, not far distant, may be taken in which it is difficult to find a trace of quartz, and which would, therefore, be placed with the syenites. In view of the sparing amount of quartz, when present, and of the geological identity of the quartzose varieties with the quartz-free, it has been found convenient to refer generally to these rocks as syenite, particularly those of the peripheral zone of the Stanjikoming area. When foliated they are called syenite gneiss. It is, however, just as difficult to draw a hard line between the foliated and non-foliated varieties of those rocks as between the quartzose and quartz-free. The one grades into the other, and rocks which are non-foliated may sometimes be referred to as gneisses, because of their being a mere local facies of a mass which is prevailingly foliated or gneissic. Although distinctly foliated, the rocks here considered rarely, if ever, assume that evenly parallel lamination or banding which is commonly observed in the biotite gneiss.

Stone-dam Lake.

The Laurentian formation with which the Keewatin rocks are in contact at the north end of Stone-dam Lake is a coarse-textured, hornblende-granite gneiss. In thin section (375) it is seen to be made up of a granular aggregate of orthoclase, plagioclase, hornblende and quartz, with some rounded prisms of apatite, a few grains of magnetite and a little secondary biotite and epidote. The quartz is in large water-clear grains, including apatite and other less determinate microlites. The orthoclase is partially altered to kaolin and muscovite. The plagioclase is usually fresher, but is occasionally cloudy. There are included in it long, perfectly straight, extremely fine rods which are sometimes in perfect continuity for great lengths and sometimes disjointed. Part of the hornblende is somewhat fibrous, and has associated with it epidote as an alteration product. On its margin it is in places altered, also, to biotite, which in turn has epidote developed in it.

North shore Loon Lake.

Another specimen from this part of the zone, taken from the north shore of Loon Lake, is a coarse, foliated, mottled, black-green and white granite. Under the microscope (525) the structure is granular. The orthoclase and plagioclase are usually quite fresh, with exceptional small patches of decomposition products. The hornblende is in

deep green colored, compact grains, with sometimes a nuclear, light yellowish colored portion, which shews brilliant polarization colors and large extinction angle, evidently the remains of an original pyroxene of which the hornblende is a paramorph. The cleavage of the pyroxene is coincident; and the latter, although not at all fibrous, appears to be developed along the cleavage of the pyroxene well within the nuclear area occupied by it. Biotite is sparingly present associated with the hornblende, from which it is probably derived. Epidote occurs in large, yellowish masses with well defined cleavage ($\infty P\bar{\infty}$) to which the extinction is parallel. It is sometimes associated with the hornblende, but is often quite apart from it. Apatite is of rather frequent occurrence in small oval and stout columnar crystals shewing pyramidal terminations.

On the shores of the north-west arm of Jack-fish Lake, the same geological mass or zone is represented by a coarse-textured, flesh-tinted rock made up, so far as can be determined, macroscopically, of felspar and black hornblende. Under the microscope (562) the hornblende is compact and of a deep color, with the usual pleochroism, and is frequently observed to have a core of foliated pyroxene. The pyroxene (diallage) polarizes in brilliant colors and shews a high extinction angle, it is colorless and not perceptibly pleochroic. The encroachment of the paramorphic hornblende upon the pyroxene along the cleavage traces is shewn very beautifully. The felspars are cloudy orthoclase, microcline and fresh plagioclase, with inclusions of apatite. Larger crystals of apatite and sphene in idiomorphic development are sparingly distributed. Small quantities of brown mica and a very little quartz are also present. Epidote occurs in separate, well-formed, pleochroic crystals of greenish-yellow color, often with an opaque nucleus of iron oxide. It also occurs in the plagioclase. Besides this, chlorite is present as an alteration product of the hornblende. Jack-fish Lake north-west arm

Another specimen from the south-west side of the same bay is a coarse-grained, pepper-and-salt, grey, hornblende and felspar rock. Under the microscope (560½) the structure is granular. The hornblende possesses distinct cores of foliated pyroxene (diallage) which demonstrate very perfectly the secondary origin of the former, and point to the paramorphic derivation of all the hornblende in these rocks from pyroxene of some form or another. The diallage appears to pass into a pale, green colored variety of the hornblende first, and then into deeper colored varieties, the pyroxene itself being of a light grey to lavender color, and very slightly pleochroic. The angle of extinction is about 40°, and the polarization colors are the brilliant ones common the pyroxenes. Plagioclase and orthoclase are present in abundance, but the former predominates very much over the latter. Cores of pyroxene in hornblende.

Apatite is fairly abundant as an inclusion in the other minerals, and biotite is present but is probably an alteration product of the hornblende with which, together with epidote, it is closely associated. The remains of foliated pyroxene and the preponderance of plagioclase taken together with the granular structure, suggest that this rock perhaps belongs with the gabbros rather than the syenites.

Foot-print Lake S. W. side.

On the south-west side of Foot-print Lake, the biotite gneiss is interrupted by a rather ill-defined area of hornblende syenite. The rock is a coarse-textured aggregate of flesh-tinted to red felspar and greenish, black hornblende. Under the microscope, the structure is granular, and the section (642) is made up of fresh microcline, inter-grown with albite, giving regular perthitic structure; plagioclase, slightly cloudy, in patches; compact, green hornblende, with occasionally a core of the original pyroxenic mineral to suggest the secondary origin of all the hornblende. Sphene and apatite are generally distributed, though not abundant, the latter in stout, rounded or pyramidally terminated prisms, and the former in its characteristic double-wedge shaped forms. Epidote is plentiful and has, in some instances, apparently been formed around a grain of magnetite or other iron oxide, but is generally associated with the hornblende from which, and from the felspar it is derived. A small proportion of the hornblende or of the pyroxene of which it is a paramorph, has been changed to nearly isotropic chlorite.

Foot-print Lake lower end.

At the lower end of the same lake, the rock, evidently the same geologically as the last, is a coarse-textured, salmon-tinted gneiss, made up of felspar with a small proportion of epidote and chlorite in rough but distinct gneissic arrangement. Under the microscope (646) the felspars are seen to be fresh orthoclase, microcline and plagioclase (albite). The lamellæ of the latter are frequently bowed and the twinning of which they are indicative is, in some instances, probably secondary and due to pressure. Other pressure effects are observable, such as the minute faulting and dislocation of crystals, and the abrupt termination of twinning traces upon cracks.* The pyroxenic or hornblendic constituents of the rock have been so decomposed that they are represented now only by intermingled aggregates of epidote and chlorite. The only other minerals observed are a little limonite and some secondary quartz.

North-west Bay Rainy Lake.

At the west end of the North-west Bay of Rainy Lake a decomposed syenite rock interrupts the biotite gneiss much as it does on Foot-print Lake. It is a coarse-grained, granular aggregate of flesh-red felspar, faded-green hornblende and yellow-green epidote. Under the microscope (918) the felspars comprise orthoclase, microcline and

* Cf. Judd. Tertiary and Older Peridotites of Scotland, Q. J. G. S., 1885.

plagioclase with inclusions of apatite. The hornblende is very largely altered to epidote, which is closely associated with it. Besides this there is an abundance of epidote, in large masses and in aggregates of grains, whose origin is less apparent. Quartz is only sparingly present, and is dusty, with liquid and granular inclusions.

On the Manitou Canoe route from the Devil's Cascade to Cedar Narrows, on Pickerel Lake, the whole breadth of the peripheral zone of the Stanjikoming Laurentian area, is well exposed. The rocks are gneissic, hornblende-granites and syenites, of which a number of typical specimens have been critically examined. Half a mile above the Devil's Cascade, the rock is a grey, distinctly foliated gneiss, which in thin section (951) is seen to be a granular aggregate of orthoclase, plagioclase, hornblende and quartz, with some idiomorphic apatite included in all these, and epidote in considerable abundance associated with the hornblende. The felspars are all fresh and the hornblende is compact, but of rather pale shades of green, and not so strongly pleochroic as it is usually; it is in irregularly shaped grains, which, however, are generally elongated in the direction of the prism. The quartz contains, as inclusions, long, straight, extremely fine, rod-like bodies. Above Devil's Cascade.

About a mile W.N.W. of the last locality, on the shores of Sphene Lake, the rock is of the same microscopic characters. Microscopically (959) it is a granular aggregate of orthoclase, microcline, plagioclase, hornblende and quartz, the last in sparing quantity. The accessory idiomorphic constituents are brown, pleochroic sphene, apatite in jointed needles and oval bodies, a few zircons, and a slender, pink-tinted, limpid, pleochroic prism, with parallel extinction, and low refractive index, probably tourmaline. The latter is included in the orthoclase. The felspars are fresh, and there is probably more than one variety of plagioclase, some of the crystals shewing broad twinning lamellæ, while in others these are excessively fine. The hornblende is compact, deeply colored and stoutly pleochroic. It is usually full of inclusions of apatite, sphene, and grains of magnetite. The quartz plays a very subordinate rôle, and may be regarded as an accessory. Sphene Lake.

A mile and a half north of the Devil's Cascade, on Sphene Lake, the rock is very much the same as that last described, a distinctly gneissic, coarse-grained, hornblende-syenite, with accessory quartz, apatite and sphene, together with a little secondary biotite associated with the hornblende. The quartz is dusty, with inclusions of an indeterminate character, together with microlites of apatite, small, stout, brown bodies and long, straight, excessively thin rods, probably rutile, many of which have a parallel arrangement, but which, taken altogether, have no apparent regularity. The most interesting point to be observed in the

Twinned sphene.

section (961) of the specimen from this locality is the beautiful instance of the twinning of sphene according to the law first described by Dr. G. H. Williams,* as explanatory of the apparently perfect cleavage in

Fig. 11. Section of hornblende-syenite gneiss from west side of Sphene Lake shewing a crystal of titanite polysynthetically twinned parallel to—4 P (Dana), probably as a result of pressure. Nicols +. × 44.

t. Titanite	*a.* Apatite
o. Orthoclase	*b.* Biotite
h. Hornblende	*q.* Quartz
p. Plagioclase	*p′.* Plagioclase, dislocated, and shewing pressure twinning.

American varieties of this mineral. The spheno is rather abundant in brown, slightly pleochroic crystals of the usual double-wedge shape, and the crystal shewing the twinning parallel to —4 P (Dana) is cut approximately perpendicular to the prismatic zone. The aspect of the crystal between crossed nicols will be gathered from a glance at (Fig. 11). There is a well pronounced set of lamellæ of varying width, inclined at a small angle to one of the prismatic faces; and feeble traces of another set of polysynthetic lamellæ are also observed as nearly parallel to the other prism, or inclined to the first set of lamellæ at an angle of 113°. This twinning law, which gives rise to the parting commonly regarded as cleavage in the largest sphenes found in many crystalline limestones does not seem to have hitherto been observed in the sphenes occurring in massive rocks. Dr. Williams in his paper, suggests that this twinning is probably due to pressure, and its occurrence, in the present instance, is under such conditions as lend interesting confirmation to this view. Faulted and secondarily

Probable pressure effects.

* Cause of the apparently perfect cleavage in American sphene, Am. Jour., Sci. XXIX, June, 1885.

twinned plagioclase occurs in such relation to it as to shew that there must have been pressure exerted at right angles to the best developed twinning lamellæ, while at right angles to the feebly developed lamellæ, there is no such evidence of pressure.

Cedar Narrows.

At Cedar Narrows, Pickerel Lake, the gneissic hornblende-syenite is in contact to the north with dark green, hornblende schists. Near the contact the syenite gneiss loses its foliated aspect, and becomes very much darker in color, the hornblende greatly predominating, and at the contact, the appearance is such as might be produced by a partial fusion of the green schists and their absorption into the magma which solidified as the syenite. There is a transition of several yards between the schists and the coarse-textured, foliated, black and white syenite, whose general character may be described as that of an aggregate of hornblende crystals in which are included reddish crystals of orthoclase. Under the microscope (1054 A) this transition rock is seen to be made up, besides orthoclase and hornblende, of large quantities of epidote and zoisite, with muscovite, derived from the decomposition of the felspar in scattered shreds. In another section (1054 B) of the same rock, where it is coarser-grained and farther from the contact, the structure is that of a hornblende syenite. The hornblende sometimes shews a pale colored central area, suggestive of its derivation from pyroxene, and carries numerous inclusions of apatite, besides which there are larger oval apatite crystals scattered through the slide. The felspar is cloudy and is sometimes stained red with oxide of iron. Epidote occurs in large individuals and in aggregates of grains.

Transition rock at contact.

Among these hornblende-syenite and granite gneisses the most interesting point, is, perhaps, the frequent detection of either a pyroxene core, or evidence of the former presence of one, in the middle of the hornblende crystals, demonstrating the secondary origin of a portion at least of the hornblende of these rocks. This, of course, raises the question of the extent to which the hornblende is secondary; and it seems not improbable that all the hornblende of the hornblende-syenite and granite of this region is of secondary origin. Such a view appears to be quite in harmony with the growing conviction of petrographers and geologists as to the general paramorphic origin of hornblende in cases where it is not distinctly basaltic. Irving* sums up his conclusions, at the end of a valuable paper on this question, in these words: "Thus, after an examination of about a thousand thin sections, representing the crystalline schists, acid eruptives and basic eruptives of a region some 400 miles in length by 300 in width, and of three distinct geological systems, I have found no hornblende that is

Secondary character of hornblende.

Irving's conclusions.

* On the Paramorphic Origin of Hornblende of the Crystalline rocks of the North-western States. Am. Jour. Sci., 1883. Vol. XXVI, p. 27.

Wadsworth. not either clearly, or very probably secondary to augite." Wadsworth had previously expressed a similar opinion with reference to the greenstones of the Marquette district.* The development of the idea of the secondary origin of hornblende is succinctly sketched by Dr. Williams and a number of instances are described by him shewing the passage of augite into compact hornblende.† In view of these and many other observations, and of the fact that the hornblende of the syenite and granites of this region frequently has a remnant of the original pyroxene clearly discernable in its centre, I feel warranted in stating that these rocks, hornblende-syenites and granites, foliated and non-foliated, seem to bear the same relation to pyroxene-syenites and pyroxene-granites as do many of the old greenstones, commonly called diorites, to original diabases and gabbros.

Williams.

Mica-Syenite Gneiss and Biotite-Granite Gneiss poor in Quartz.

Texture and structure.

These rocks resemble closely the foliated, hornblende syenites and granites in their conditions of occurrence, but are sometimes in geographically separate masses. Their texture is coarse to very coarse, and they are usually of gneissic habit, although they can be traced into varieties in which it is difficult to detect any sign of foliation. They are usually characterized by the porphyritic development of orthoclase in large crystals twinned according to the Carlsbad law, and, when the rock is gneissic, the long axes of these porphyritic crystals are in parallel alignment. The planes of foliation are, however, in their detail undulatory, owing to their flowing around the large felspars as in the case of augen gneiss. It occasionally contains rounded or ovoid secretions of finer grain, or more rapidly cooled portions of the rock which are of identical composition with the bulk of the rock mass.

Falls of Fort Frances.

The rock at the Falls of Fort Frances on Rainy River belongs to this class. On the islands below the fort and on the shores of Sand Bay, the same rock is more distinctly foliated than it is at the falls. A section (65) of this rock shews it to be a granular aggregate of orthoclase, plagioclase and biotite, with a little accessory hornblende and quartz, in which are imbedded porphyritic crystals of orthoclase. Other accessory constituents are sphene, apatite and magnetite. The twinning lamellæ of the plagioclase are very fine and the extinction determined on a cleavage slice parallel to $\infty P \breve{\infty}$ is about 1°, so that it is very probably oligoclase.

Sand Bay, Rainy Lake.

At the bottom of Sand Bay, near the Half-breed village, the rock is much the same as that at the falls, but it is distinctly gneissic and

* Bull. Mus. Comp. Zool., 1880, pp. 37, 39, 42, 46.

† On the Paramorphosis of Pyroxene to Hornblende in Rocks. Am. Jour. Sci., 1884, Vol. XXVIII, p. 259.

shews areas of finer grain enclosed in the coarser, probably as earlier secretions. The composition and structure of these, as revealed by the microscope, present no marked difference from the rest of the rock except in the texture. The thin section (662) is that of a granular aggregate of fresh plagioclase, orthoclase, biotite, hornblende and quartz, with some epidote.

Another specimen of this same gneiss was taken from the east side of Stanjikoming Bay near the channel leading into it from the lake. The rock is here a coarse, grey gneiss with porphyritic crystals of orthoclase in Carlsbad twins. Under the microscope (793) it is a granular aggregate of orthoclase, microcline, plagioclase, biotite and quartz. Apatite and sphene are accessory original constituents and limonite and epidote secondary products. None of these are very abundant. The quartz is in sparing quantity and is intergrown with orthoclase in micro-pegmatitic structure. Only an occasional crystal of hornblende is observable. The epidote is derived apparently from the biotite with which it is associated as large, well-formed crystals of yellowish color. **Stanjikoming Bay.**

Farther north, on the west side of Rainy Lake, three-quarters of a mile N.N.W. of Standing-stone Point, a decomposed, flesh-red, porphyritic gneiss of coarse-texture interrupts the biotite gneiss of that part of the lake. It is made up of large crystals of felspar around which the micaceous constituents flow. Under the microscope (833) the felspars are seen to be orthoclase, microcline and plagioclase with some included zircons. The mica is altogether changed to epidote and chlorite, there being none of the fresh mineral left. A little leucoxene is also present. **Near Standing-stone Point.**

Biotite Gneiss.

The biotite gneisses of the region have not been made the subject of extensive microscopic study, such an investigation being unnecessary for ordinary determinative purposes. A few typical specimens from different parts of the region have, however, been examined, chiefly with the object of instituting a comparison between the minute structure of the more distinctly foliated and the less or non-foliated varieties. Such a comparison failed to establish any essential distinction between the two varieties beyond that observable with the naked eye in the parallelism of arrangement of the constituent minerals in the gneiss as contrasted with their indiscriminate disposition in granite. In both the structure is granular. **Comparison of foliated and non-foliated varieties.**

At the south end of Crow Portage, Sabaskong Bay, the gneiss which has been described as forming a brecciated contact with the basal, hornblende schists of the Keewatin series, is a medium grained, flesh- **Crow Portage.**

tinted to grey rock of unusually even foliation. In microscopic section (48 B) it is seen to have a well-defined granular structure, all the minerals being allotriomorphic, except a few large porphyritic felspars of an earlier generation than the mass of the rock. The constituents are quartz, orthoclase, plagioclase, and biotite. The last mentioned mineral always lies in definite parallel planes, while the quartz and felspar grains exhibit a corresponding but much ruder tendency to a similar arrangement. The felspars are usually quite fresh. When decomposed to kaolin or muscovite, the decomposition is nuclear or central rather than marginal, and shews itself in sporadic flakes or cloudy aggregates sometimes along cleavage lines. The orthoclase is occasionally seen in Carlsbad twins, and the plagioclase is as usual twinned on the albite law, or a combination of this and the péricline law. The felspars are occasionally observed to be broken and parted with a shear, the intervening fissure being filled with secondary quartz or muscovite. The quartz carries inclusions of apatite, liquid inclusions with dancing bubbles, and darker bordered round inclusions, probably of gas, besides dusty or granular indeterminate matter.

Loon Lake.

On the south side of Loon Lake, on the Pipestone canoe route, there is an extensive exposure of the biotite gneiss of the inner nucleus of the Stanjikoming Laurentian area. A specimen taken from the west side of the lake, about a mile north of Speak-no-bad-language Portage is an evenly, foliated, flesh-tinted to grey, fine-grained rock. Microscopically (476) it is built up of allotriomorphic grains of quartz, orthoclase, plagioclase, biotite and epidote, the structure of the rock being granular. Quartz is the most abundant mineral. It contains fluid inclusions with moving bubbles, fine straight, rod-like bodies, probably rutile, and besides these a number of small yellowish, highly refracting, oval or oblong bodies. The orthoclase is perfectly fresh, and is only distinguished from the quartz by the bluish color between crossed nicols and its biaxial interference figure in converged polarized light. The plagioclase is also quite fresh and is as usual recognized by its polysynthetic twinning. The biotite is of a greenish, brown color. Stout, oblong crystals of apatite and epidote, in aggregates of grains are also present.

Stanjikoming Bay.

The medium grained, biotite gneiss on the west shore of Stanjikoming Bay, towards its north end, differs but little from that last described, except that it is much less distinctly foliated and looks more like an ordinary grey granite. In thin section (776) the structure is granular. The felspars are usually fresh and the plagioclase is probably more abundant than the orthoclase, although the rock is decidedly quartzose. Apatite and sphene are sparingly present. The biotite is in places altered to chlorite.

From the west coast of Rainy Lake, about two miles north of the entrance to Stanjikoming Bay, a specimen was taken which may be regarded as typical for a very large proportion of the gneiss of the inner nucleus of this Laurentian area. It is a medium-textured, evenly foliated, biotite gneiss, which, in thin section (801), appears as a granular aggregate of quartz, orthoclase, plagioclase and biotite, with sphene and apatite as accessory constituents in their usual idiomorphic forms, included in the first named minerals. Besides these there are a few small, stout, highly refracting, brilliantly polarizing bodies which are probably zircons. Some epidote, derived from the mica and a few grains of magnetite complete the list of constituents. The quartz is water-clear and shows streams or rows of liquid inclusions with moving bubbles. This mineral shews in all its sections a strongly marked undulatory extinction. The undulatory character manifests itself in two ways, (1) the extinction passes across the quartz section like a wave, as is ordinarily the case when a crystal is subject to unequally distributed tension, and, (2) a somewhat abrupt break in the optical orientation in different parts of the crystal without any apparent break in its individuality. The angle, however, through which the stage of the microscope must be revolved to make these diversely orientated portions of the same individual coincide in intensity of extinction, is very slight. West coast Rainy Lake.

Of the more granitoid or less foliated varieties of this gneiss, a specimen from the north side of the Open-water Narrows is a good example. Under the microscope (1464) it appears as an aggregate of orthoclase, microcline, plagioclase, quartz, biotite, muscovite and some epidote. The rock has a granular structure and is a true granite according to Rosenbusch's classification since it contains the two micas. The foliation is only observable on the large scale. Open-water Narrows.

On the north-west side of Pipestone Lake a mass of granite breaks through the Keewatin schists, which appears to be identical geologically with the Laurentian granite and granitoid gneiss of Kishkutena Lake which pass into distinctly foliated gneisses along the route to Sabaskong Bay. A thin section (326) of this rock is seen under the microscope to consist of hypidiomorphic orthoclase and allotriomorphic quartz and plagioclase with bleached biotite. The accessory minerals are apatite, sphene, magnetite, and leucoxene. The orthoclase is usually quite decomposed, the kaolin and muscovite having often a very distinct zonal arrangement. The sphenes are in sharply defined crystals, often surrounded by a rim of varying width of grey or brownish leucoxene. The biotite is often of a green color, and has epidote associated with it. Pipestone Lake.

Clear-water Lake, east side.

On the east side of Clear-water Lake, Kishkutena route, the peripheral zone of syenite gneisses of the Stanjikoming Laurentian area, presents the local facies of a medium-grained, flesh colored granite of porphyritic aspect which, in places, is distinctly foliated. In thin section it consists of large idiomorphic or hypidiomorphic crystals of felspar (orthoclase, microcline and plagioclase) and allotriomorphic quartz, felspar and biotite, the latter mostly altered to chlorite and epidote. The felspars, even when quite allotriomorphic, shew a distinct zonal structure, the different zones having a different optical orientation, indicating difference of composition. The decomposition in some zones is much greater than in others, so that the alteration products have a zonal arrangement. The quartz is water-clear and comparatively free of inclusions. A few small sphenes are present.

Laurentian gneiss at contact with Coutchiching.

The Laurentian gneiss at the contact of that formation with the schists of the Coutchiching series on a small island three miles east of Coutchiching, is a grey, medium grained, distinctly but not evenly foliated rock. It forms the matrix in which are imbedded the detached fragments of Coutchiching schist shewn in Plate I. Under the microscope (693) it is an eminently granular aggregate of grains of orthoclase, plagioclase, quartz and biotite. The felspars are partially decomposed, the cloudy, grey kaolin exhibiting a definite zonal arrangement, though occasionaly confined to the central portion of the crystal. Shreds of muscovite are generally distributed as an alteration product of the felspar. The biotite is only sparingly represented. It is often bleached green, and is then usually associated with epidote into which it has partially altered. Apatite occurs included in the biotite. Pyrite is also present in small quantity and limonite in various brown grains.

Inclusions in Laurentian Gneiss.

Shape of inclusions.

The Laurentian gneisses of the region, both of the granite and the syenite type of composition, frequently form a matrix in which are imbedded portions of foreign rock either as sharply angular, sub-angular, or somewhat rounded blocks, or as more or less attenuated bands drawn out parallel to the foliation of the gneiss and confused with it. This phenomenon is perhaps more commonly observed in the granite gneisses than in the syenite gneisses. As in the Lake of the Woods region these inclusions are most abundant in the vicinity of lines of contact with over-lying rocks. They are, for the most part, indistinguishable from the basal portions of either the Keewatin or the Coutchiching series. Where they present points of difference, the difference is such as is readily

explicable as a result of the conditions to which the inclusions must be conceived to have been subjected. Near the contact with the Coutchiching series the Laurentian gneiss holds as inclusions generally only fragments which are identical with Coutchiching rocks where examined *in situ;* whereas near the contact of the Laurentian with the Keewatin fragments resembling the Coutchiching rocks are very rarely met with, and those resembling the basal formation of the Keewatin abound. These facts, taken in connection with the prevailingly shattered character of both the Coutchiching and Keewatin strata at the contact with the Laurentian gneiss, which allows apophyses or dykes from the main area of gneiss to ramify through the schists both parallel and transverse to their planes of schistosity, leave no room for doubt but that these inclusions are detached portions of overlying formations, which, in a firm and brittle condition, have become immersed in the underlying viscid magma which subsequently crystallized out as the Laurentian gneiss and granite. It seems probable, too, that such shattering and detachment of fragments took place at the last stages of crumpling of the crust in this region. This opinion is based on the fact that while both the Coutchiching and Keewatin rocks afford ample evidence of having yielded to pressures and earth stresses, the Laurentian gneisses do not, except very locally, and to an insignificent extent. This fact proves that after the solidification of the Laurentian gneisses there was no farther very violent deformation of the crust and no shattering subsequent to the time at which those gneisses were solid, hard rocks as they are now. All the violent disturbance of the region, and the folding and crumpling of the strata of the Coutchiching and Keewatin series appears to have transpired antecedent to the final solidification of the Laurentian rocks, and while the latter were yet in the form of probably a thick, viscid magma upon which floated the slowly shrinking and crumpling strata of the Coutchiching and Keewatin series. The scattered fragments of the overlying series which we now find imbedded in the Laurentian gneiss do not, of course, represent the whole of the shattering and decrepitation, as it were, of the overlying rocks. Large portions of these rocks have very probably been absorbed by fusion with the magma, for the Laurentian rocks appear to have resulted from the fusion not simply of the floor upon which the Coutchiching and Keewatin rock first rested, whatever such floor may have been, but, also, with it, of portions of those series. The inclusions which we now see are probably only those fragments which were detached, as I have stated, at the later stages of the development of the Laurentian gneiss, when the heat was less intense and the temperature of the magma was approaching the fusion point or the point of solidification, for the pressure and other modifying influences to which it was subjected.

Comparison with Keewatin and Coutchiching rocks.

Shattered character of strata at contact with Laurentian.

Period of shattering.

Probable absorption.

Meaning of contact of upper and lower Archæan.

This conception of the development of the Laurentian gneiss, which seems necessary in order to give a consistent explanation of all the phenomena of this field, involves the belief that the present line of demarkation between the lower and upper Archæan, or the contact of the Laurentian with either the Coutchiching or Keewatin, represents what was once the contact of the lower surface of the crust, in this region at least, with the magma upon which it rested.

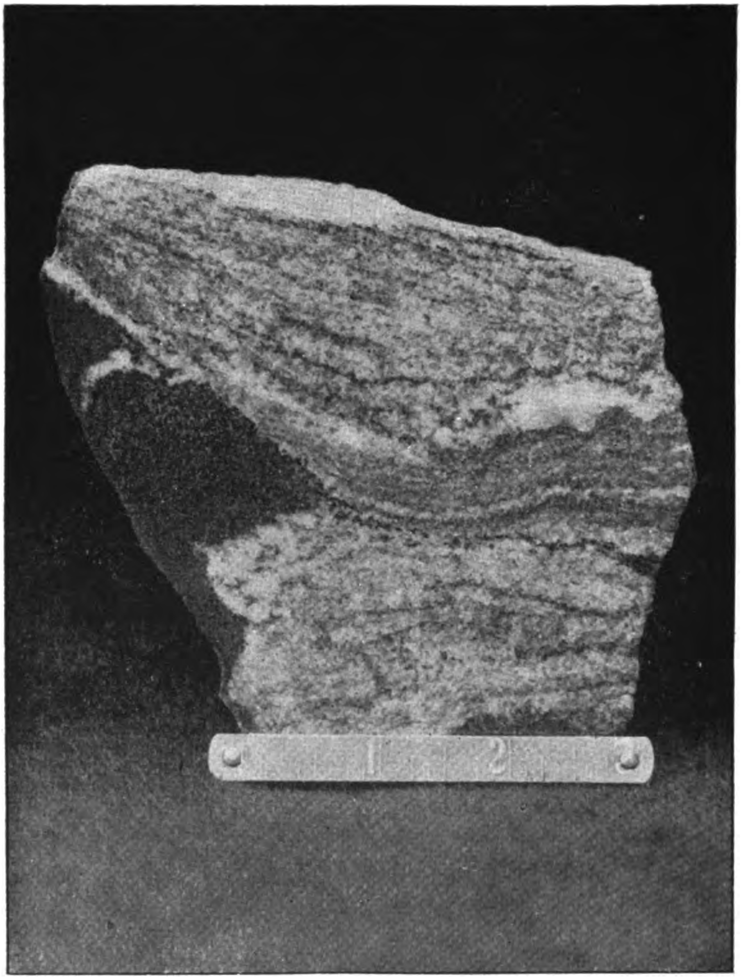
Inclusions in gneiss remote from contact.

While these inclusions are, as a rule, most abundant near the contact of the Laurentian with the Keewatin and Coutchiching series, they are by no means wanting in the gneisses many miles remote from such contact. On the shores and islands of Sabaskong Bay there are revealed the most unequivocal evidence of the brecciated contact of Laurentian and Keewatin rocks, the penetration of the latter by the former, and the inclusion of angular broken pieces of the Keewatin schists within the gneiss. Scores of the the most beautiful instances of fragments and groups of fragments of rocks indistinguishable from those which form the base of the Keewatin, may be seen in a day's paddle among the well bared rocky islands of this intricate labyrinthine portion of the lake. They occur here almost as abundantly away from the contact as close to it. So long as these inclusions retain their broken angular shapes, there is never any confusion of their boundaries with the enclosing gneiss. The contrast of matrix and inclusion is as sharp and distinct as it possibly could be, and indeed much more so than one would naturally expect. The size of the fragments varies usually from the dimensions of one's fist to those of a house. Many are much larger than a house, but these are not always traceable around their entire contour. Some are acres in extent, and some take the form of bands one or several miles in length, by hundreds of feet in breadth, which, in single sections, might easily be mistaken for inter-stratifications with the gneiss. When groups of these fragments are found in the gneiss together, they are arranged more or less distinctly in lines corresponding with the foliation of the gneiss, and the whole appearance of the horizontal section, presented by the glaciated surface of the rocks, is suggestive of the thick, crystallizing magma, in which they were once immersed, having been subject to a fluxion or flowing, to which is due both the foliation of the gneiss and the alignment of its included fragments of foreign rock.

Conditions observed on Sabaskong Bay.

Microscopic characters of inclusion.

A specimen of one of these angular inclusions in biotite gneiss taken from an island south-east of Rabbit Point, Sabaskong Bay, is a glistening black to iron grey schist made up of glistening hornblende in minute needles, and a greyish-white mineral, which modifies the color of the schist, but which is too minute to show crystal faces to the naked eye. In thin section (1709) the rock is seen to be banded, owing to the dis-



G. E. DESBARATS & SON, ENGRAVERS & PRINTERS, MONTREAL.

Polished surface of specimen of biotite gneiss, with included fragment of amphibolite partially drawn out into a "tail." West side of Jackfish Lake, Pipestone route.

tribution of the hornblende. All of the latter mineral occurs in compact, stout prisms or needles arranged parallel. In certain parallel linear areas, however, these hornblende prisms are much larger than in the rest of the section, and are much more closely crowded together, with but little interstitial space. In the broader areas lying between these, the hornblende prisms are much smaller and much less crowded, the interspace being occupied by felspar in small irregular grains with some quartz. In exceptional areas the felspar predominates, and the hornblende prisms stand out very sharply in direct light from the colorless base, and present an appearance analogous in miniature to a bird's eye view of a run of saw-logs in a broad stream. Grains of magnetite are scattered throughout the section.

The description of the microscopic characters of this specimen shows that it differs in no essential feature from those rocks of the Keewatin series which have been classed as hornblende schists, and described in a previous part of this report.

Cases of apparent fusion of inclusions with matrix.

In many instances, however, these inclusions, as observed on Sabaskong Bay and elsewhere, have lost their sharply angular contours and have rounded, oval, or more or less attenuated, lenticular shapes. In these cases the line of demarkation between matrix and inclusion becomes less sharply defined, and in many cases there is evidence of the included fragment having been reduced by total or partial fusion to a condition admitting of its deformation and drawing out into lenses. In these cases the condition of fusion must have been one of thick viscidity which did not permit of the complete mingling of the magma of the inclusion with that of the matrix or gneiss. In those cases where magmas had by higher temperatures been sufficiently liquid to mix, the inclusions have probably been entirely absorbed by the gneiss leaving no trace of their existence, except a more basic local facies of the gneiss. When the inclusions have been so deformed and drawn out by partial fusion and recrystallization, there is a partial admixture of the two at the contact, and a transitional rock exists which is midway in character between the matrix and the inclusion. The inclusion in these cases, too, has lost its schistose character, and has become more felspathic in composition and more granular in structure, having the facies of a diorite. The felspar seems to have been absorbed from the inclosing magma probably rather by the agency of the penetrating watery solutions from the granite magma, than by a direct addition of a portion of the latter in the dry state.

Inclusions on Jackfish Lake

A good example of this kind of inclusion is one taken from the west side of Jackfish Lake, Pipestone route. Here the biotite gneiss assumes locally the aspect of a breccia, in which a very quartzose, biotite gneiss forms the matrix for angular blocks of foreign rock of an essen-

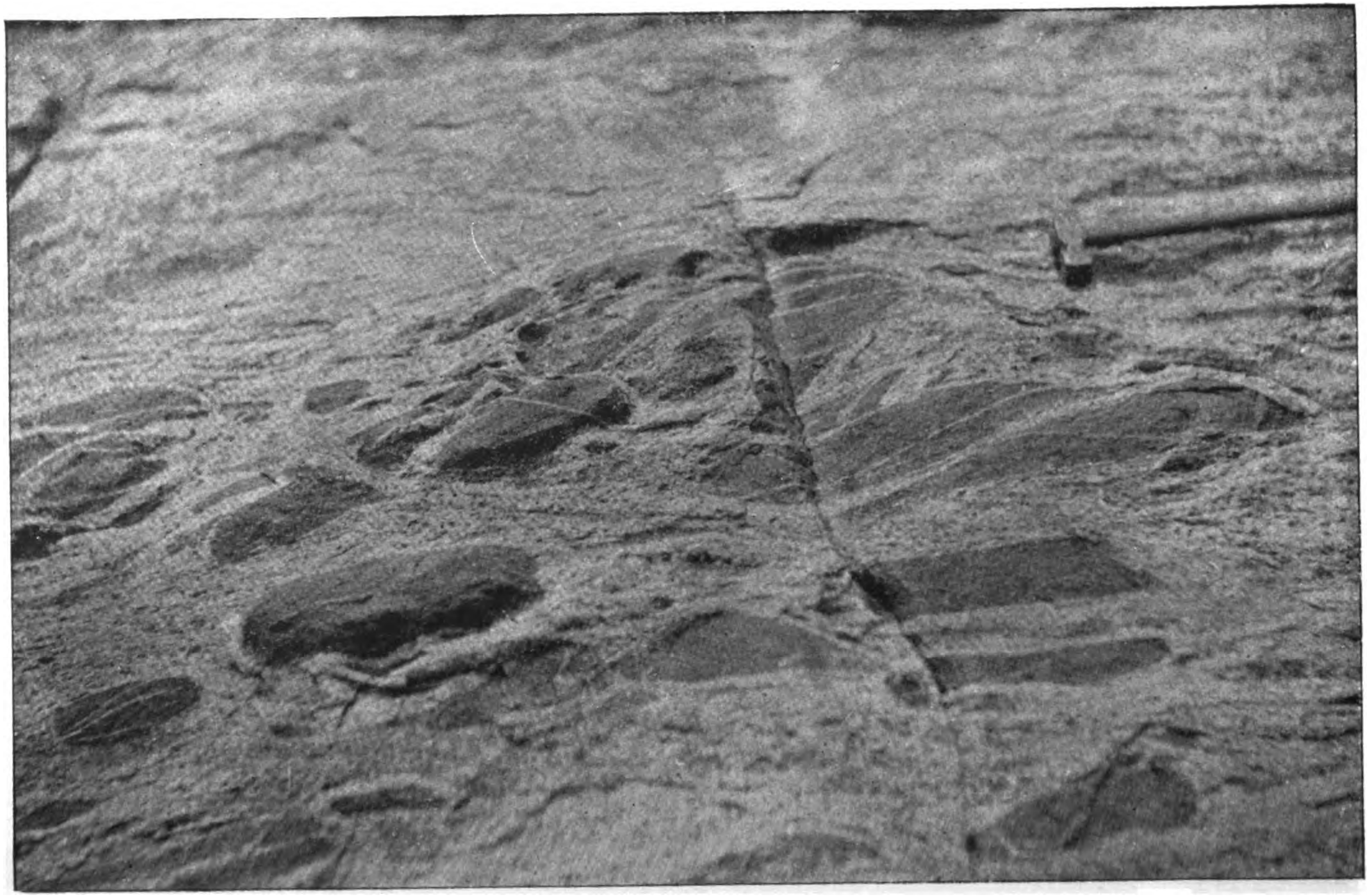
tially hornblendic or dioritic character. The specimen taken is from the shore about two miles north of Foot-print Portage. It is of interest as shewing on the small scale in a hand specimen a condition of things which is very common on the large scale, and yet difficult to describe clearly without specimens. In the field the foreign and included character of the angular blocks of amphibolite or diorite is very apparent and can be examined critically in numerous well-exposed examples on the glaciated surfaces of the country rock. The specimen in question was cut through the middle and polished. Plate IV is a reproduction of a photograph of the polished surface, and shews the sharp well-defined character of the inclusion. The foliation of the gneiss flows around the inclusion, and the longest diameter of the irregularly shaped fragment lies parallel to the general trend of the foliation. A portion of the fragment has been drawn out into a "tail" analogous to those which may be observed in the porphyritic crystals of quartz-porphyries, and other rocks that have been subjected to excessive pressure. The two cases are, however, not entirely analogous, for the "tail" of the lenses in squeezed porphyries seems to be due to actual rupture of the solid brittle crystal, with probably a certain amount of recrystallization, while the "tail" of the dioritic inclusion in the biotite gneiss would seem to be due to a partial fusion and recrystallization of the hornblendic material, while the matrix was in a plastic condition and in process of solidification. On the large scale, by a similar process, blocks seem to have been, under the combined influence of pressure and partial fusion, drawn out into flat sheets which have all the aspect of intercalated beds, so even and sharp is the banding, and yet so unmistakably due to a simple stretching of the viscid and crystallizing magma with its included blocks of foreign material. The rock composing the matrix of the specimen figured is an evenly foliated grey, biotite gneiss of medium texture. Under the microscope (568 A) it is seen to be made up of a granular aggregate of orthoclase, plagioclase, quartz and biotite, with a few crystals of apatite and some secondary epidote. The felspars are fresh and glassy. The quartz is very abundant in water-clear grains with minute inclusions arranged usually in rows. The biotite is in the form of greenish-brown shreds. The epidote is in greenish-yellow crystals, and in aggregates of grains.

Stretched appearance of inclusion.

Microscopic characters of matrix.

Another thin section (568 B) from the same hand specimen was made across the line of contact of the inclusion and matrix. The line of contact was observed even in thin section to be quite sharp and decided, though not a simple straight line. The gneiss is identical with that last described. The included block is made up of a medium-grained, granular aggregate of compact, deep colored green hornblende, fresh plagioclase and quartz. Hornblende is the predominating

Microscopic characters of inclusion.



A. C. LAWSON, PHOTO., 1887 G. E. DESBARATS & SON, ENGRAVERS & PRINTERS, MONTREAL.

Angular and lenticular fragments of hornblende schist similar to that of the Keewatin series, included in Laurentian gneiss, on island off S.E. shore of Lake of the Woods, three quarters of a mile north of 49th parallel. The flow or "pulled" structure is in the field very pronounced, the fragments being arranged in streams.

mineral. There is no biotite. On the other side of the line of contact biotite is abundant, and there is no trace of hornblende to be found. The ragged character of the contact is such as would be presented by a section of the surface of a broken rock fragment of medium grain. There are traces of fusion and inter-penetration, but within very narrow limits, at the place where the section was cut. The inter-penetration is much more apparent, where the block is drawn out into a "tail."

S.E. side of Lake of the Woods.

The biotite gneiss of the south-east side of the Lake of the Woods, between the mouth of Big Grassy River and that of Rainy River is characterized by an abundance of these inclusions, in sharply angular blocks, in more or less attenuated lenses, and even in sheets which simulate strata.

Inclusions in gneiss near 49th parallel.

Plate V is the reproduction of a photograph of a horizontal glaciated surface of the rock on an island off this shore about three-quarters of a mile north of the 49th parallel. It illustrates very beautifully what is common on a scale usually much too large for photography, and shows in one small horizontal section a representative variety of the shapes of these inclusions, and their relationship to the gneiss in which they are imbedded. Some, it will be observed, have rectilinear boundaries and sharply angular contours, others are oblong in shape, but more or less rounded, and some are distinctly lenticular. The foliation of the gneiss is well shewn, as is also its flow around the inclusions. The sundering of the included fragments, the penetration of the gneiss into the crevices, the drawn out or tapering ends of some of the fragments and the alignment of all of them parallel to the foliation of the gneiss, also are features which come out very clearly in the photograph and which are full of suggestion and instruction.

Inclusions in Stanjikoming area.

The biotite gneisses of the inner nucleus of the Stanjikoming area of Laurentian rocks is, in some places, charged with these inclusions, while in others it is remarkably free from them. Here they do not always resemble the rocks of the overlying series, but are frequently very coarse-textured and massive, and would be classed as massive amphibolites or diorites rather than hornblende schists. In this connection it should be observed that on the supposition that the Laurentian gneiss is the result of the fusion and recrystallization of the floor or basement upon which the Keewatin rocks were deposited, we should expect to find other inclusions than those of rocks such as occur in the Keewatin. The Keewatin series being largely made up of volcanic rocks, the vents from which these volcanic rocks emanated must have existed in the acid crust or floor at the time the latter succumbed to the process of fusion, whatever the exact nature of that process may have been. These pipes or vents would be filled with the

deep seated, coarser, granular phases of the rocks, which, as flows and loose ejectamenta, formed the Keewatin strata at the surface. When these vents were filled with basic rock, they would, in a fusion which only reduced the rocks to a thickly viscid magma, and did not permit of their mingling, or the complete absorption of the one by the other, still retain their distinctive characters, and on solidification present a strong contrast to the general gneissic matrix. Such appears to be the probable origin of some of the more massive coarse-textured amphibolitic or dioritic inclusions in the biotite gneiss of Rainy Lake. They are usually very much more irregular in shape, and their relations to the gneiss much more confused, than in the case of those inclusions which are recognizable as identical with the schists at the base of the Keewatin. Their size varies very much, and some are so large that their character as inclusions is not directly determinable, but is inferred from their analogy with the smaller inclusions adjacent to them. They are often traversed by irregular veins or dykes emanating from the main area of gneiss. As an example of this class of inclusion, a specimen was taken from an island in Rainy Lake opposite the mouth of the North-west Bay. The inclusion is a large block of irregular outline, the greatest diameter of the exposed surface being twelve or fifteen feet. A microscopic examination of a section (3000 B) of the rock shews that it is made up of a granular aggregate of deep colored green hornblende, with a little felspar, both cloudy and glassy, striated and non-striated. A small amount of epidote is associated with the cloudy felspar. No biotite is present. The hornblende is greatly in excess of the felspar, so that the rock may be classed as an amphibolite rather than a diorite, particularly as light colored central areas occur in the hornblende occasionally, which suggest the probability of its derivation from pyroxene.

Origin of certain inclusions.

Example of a class of inclusions.

Matrix in which inclusion is imbedded.

The matrix in which this block is imbedded is a medium-grained, grey, distinctly foliated gneiss. Under the microscope (3000 A) it is made up, like the other similar gneisses of the region, of a granular aggregate of quartz with liquid inclusions having dancing bubbles, fresh orthoclase, microcline, plagioclase and biotite, partially altered to epidote. There is no hornblende present.

Gneiss of Redgut Bay.

The biotite gneiss of Redgut Bay, opposite the Indian village, is much like that already described from other localities. It is medium grained, light grey in color and distinctly foliated. Under the microscope (1600 A) it appears as a granular aggregate of orthoclase, plagioclase and biotite, the latter largely altered to epidote, together with a sparing number of apatite crystals in slender, round-ended prisms and in oval bodies.

Included in this gneiss is a dark green, medium grained amphibolite rock. The inclusions do not here retain their angular forms, but are drawn out into attenuated lenses or sheets, which have the appearance of being intercalated with beds of gneiss, and give the rock a pronounced laminated or banded structure. The appearance is, however, deceptive, and it is far more satisfactory and more consistent with all the facts observed to ascribe the banded structure not to any intercalation or stratification, for it is very local, but to the attenuation of inclusions by the combined action of pressure and a process of slow fusion and recrystallization. The amphibolite in thin section (1600 B) appears as a granular aggregate of hornblende and cloudy felspar, the former greatly predominating. Some of the felspar is striated, but for the most part the twin structure, if present, is obscured by the decomposition. **Attenuated lenses.**

The rock along the line of contact of the attenuated inclusion and the matrix of biotite gneiss is not of a simple nature, but is made up of a fused mixture of the two. This mixed character of the margin of the inclusion was observed in the field, and the conclusions there arrived at as to the relations of the amphibolitic lenses and the gneiss, and as to the conditions to which the rocks must have been subject, to produce the appearance presented, have been sustained by a microscopic study of the normal gneiss, the core of the lens and the marginal or transitional rock. This transitional rock is a mica, hornblende and felspar rock with some quartz. Microscopically, the additional constituents, apatite, leucoxene and epidote, are observable. The structure is granular, with porphyritic crystals of orthoclase, which are somewhat cloudy. Some of the biotite seems to be an alteration product of the hornblende, and much of it is observed to have altered very largely to epidote. In some of these lenses, the interfusion of matrix and inclusion has been so complete that they are entirely made up of this transitional rock, which has the facies of a syenite, while in other cases, probably where the imbedded mass has been larger, the inter-mixture has been only marginal. **Transition between inclusion and matrix.**

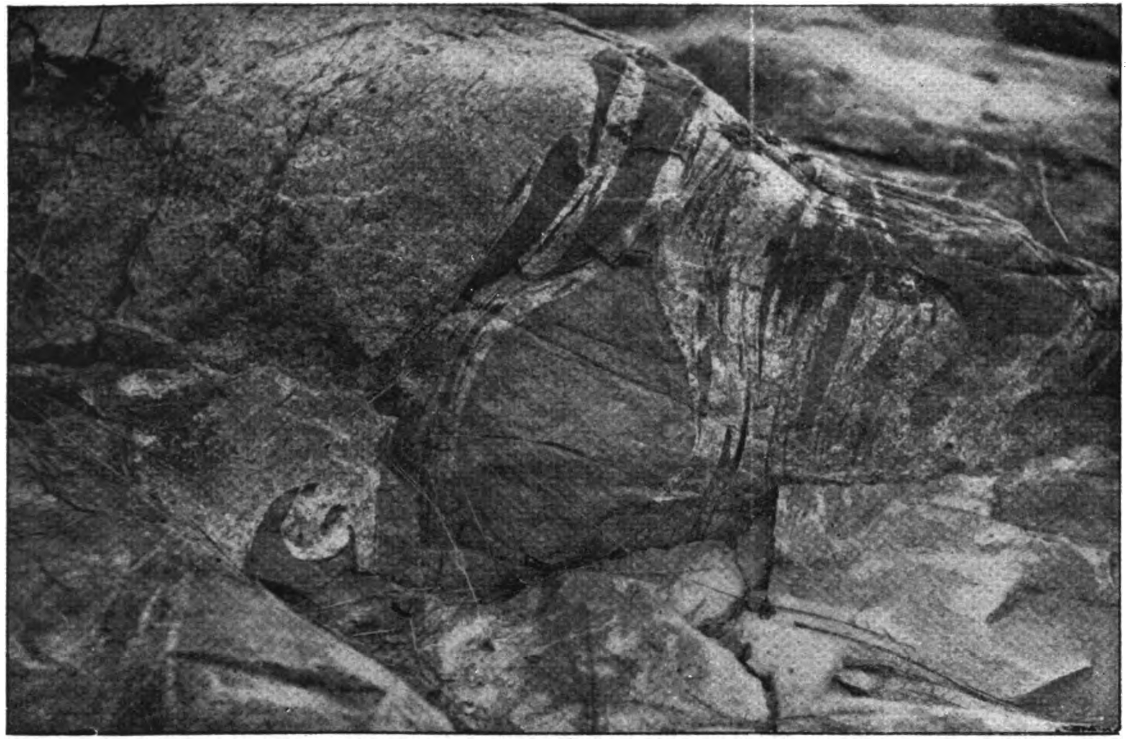
The syenite gneiss which crops out on Rainy River on Mr. Geo. Singleton's farm about six miles and a half above the Manitou Rapid exhibits some very beautiful and instructive instances of inclusions of fragments of h ornende schist. One of these is represented in Plate VI from a photograph of the bare rock surface close to the water's edge. The gneiss is distinctly foliated, as appears in the photograph. The figure illustrates, in a very forcible manner, the drawing out and sundering of the included fragments. The large, central, pear-shaped piece of schist appears to be only the remnant of a much larger block which has been reduced in size by the tearing off of fragments which **Inclusions in gneiss on Rainy River.**

are still in its immediate vicinity, and whose relationship to the central mass is quite apparent. All these detached pieces, as well as the central pear-shaped mass, have their longest diameter parallel to the foliation of the gneiss, and there seems little room for doubt but that the foliation of the gneiss and the alignment of these fragments of schist, are due to the same unequal pressures upon the mass as a whole, and to a general flow in the rock at a time when the matrix was plastic, and not yet completely crystallized. To have produced these effects, the matrix in which the inclusions are imbedded, although yielding to pressure and flowing like a liquid, must have been very nearly solid, or at all events a very thickly viscid and tough magma, such perhaps as some laboratory preparations of soluble silica, or molten glass at low temperature near the point of solidification. That the matrix could not, at the time it yielded to pressure and exercised such rending effects upon the included blocks of schist, have had the form of a crystalline aggregate such as it now is (a syenite), is shown by the fact that there is every evidence of the constituent minerals of the present rock, in all the minute crevices and corners into which it penetrates, having crystallized *in situ*, and no evidence of such minerals having been subjected to excessive pressure since the rock solidified and assumed its present form of a hornblende-syenite. The effect of the same pressure on a solid crystalline rock is seen in the shattering and sundering of the inclusion of the hornblende schist, which here seems not to have been fused to any extent, even on its edges. Had the matrix, at the time that it yielded to pressure, been a solid crystalline rock, we cannot conceive of the deformation, such as it indicated by its flow, its penetration of the schists, and its accommodation to the most intimate parts of the schist, taking place without a similar shattering of the rock, or of its constituent crystals, and without their granulation and reduction to the cataclastic state.

Conditions affecting the sundering of included fragments.

Inclusions of fragments of rocks of Coutchiching series.

In the Laurentian gneiss of the southern part of Rainy Lake there are numerous inclusions of fragments of rock which are indistinguishable from the rocks of the Coutchiching series, which is largely developed in that part of the lake. These inclusions occur both in the regular biotite gneiss and in the coarser gneiss of the syenitic type. As an instance of these inclusions in the latter rock, may be mentioned those which are observable at the north end of the island which lies opposite the entrance to Stanjikoming Bay. The inclusions are most plentiful in the gneiss in the vicinity of the contact with the Coutchiching series. Plate I. will serve as an illustration of these. It is reproduced from a photograph of a rock surface a few yards distant from the contact on an island off the south shore of Rainy Lake, three miles east of Coutchiching. The distinct character of the inclusions,



A. C. LAWSON, PHOTO., 1887. G. E. DESBARATS & SON, ENGRAVERS & PRINTERS, MONTREAL.

Fragments of hornblende schist, similar to that of the Keewatin series, enclosed in Laurentian gneiss. The fragments are arranged in a stream, and there is a distinct pulled or stretched appearance. The large, pear-shaped inclusion in the centre appears to be the remains of a larger mass, the sundering of which has given rise to the more attenuated lateral fragments. The gneiss is distinctly foliated, although it does not appear so in the illustration. Geo. Singleton's farm, Rainy River. R. XXVIII., Tp. 5 S., Sec. 8.

the foliation of the gneiss and the penetration of the latter within the fissures of the inclusions is very clearly shewn in the photograph. There is not the remotest doubt of the derivation of the included fragments from the edge of the Coutchiching formation a few yards to the south. That edge is ragged and shattered, and the schists are traversed by apophyses, from the main mass of gneiss, which retain their foliation distinctly.

Shattered edge of Coutchiching schists.

SUMMARY OF ARCHÆAN GEOLOGY.

The broad results which have been arrived at by my study of the Archæan geology of the Rainy Lake region may be briefly summarized. They are :—

Primary division of Archæan.

1. The primary separation of the Archæan complex of this region into two great natural sub-divisions, viz..: A lower division, Laurentian, and an upper division, composed of at least two distinct geological series, the Coutchiching and the Keewatin.

Laurentian.

2. The Laurentian is composed entirely of rocks, which are of the nature of granites and syenites in mineralogical composition and granular structure, but which, by reason of their more or less distinct foliation, are known as gneisses.

Irruptive and plutonic character of Laurentian.

3. Abundant evidence has been adduced to shew that these gneisses behave in all essential particulars precisely as irruptive granites do; and that they are plutonic rocks which have crystallized slowly, probably under an extremely gradual diminution of temperature from a thickly viscid, coherent or tough, hydrothermal magma.

Differential pressures on magma.

4. There is evidence that such magma, up to the time of its final solidification, when it became approximately rigid, was subjected to differential pressures, which, by causing a yielding or deformation, induced a flow in the mass. To this flow is ascribable, with great probability, both the foliation of the gneiss, and the parallel alignment of certain inclusions of foreign rock imbedded in in it, presently to be mentioned.

Origin of magma.

5. Whatever may have been the more remote history of the Laurentian rocks of this region, it appears clear that the magma from which they crystallized as foliated granites and syenites, was immediately or proximately produced by the fusion of the basement or floor upon which the formations of the upper division of the Archæan were originally deposited. With the fusion of this floor it seems probable that portions of the superincumbent strata, which once formed integral parts of either the Coutchiching series or the Keewatin, have also been absorbed into the general magma, and reappeared on crystallization as Laurentian gneiss.

Extent of fusion.

6. This fusion, however, only extended up to a certain uneven surface, which surface constitutes the demarkation between the present upper and lower Archæan.

Relation of crust to magma

7. Above this surface, or upper limit of fusion, the formations of the Coutchiching and Keewatin series retained their stratiform or bedded disposition, and rested as a crust of hard and brittle rocks upon the magma, subject to its metamorphosing influences.

Disturbance of crust.

8. There is abundant evidence that while resting on this plastic magma the crust was violently disturbed, folded, crumpled and in places shattered. This disturbance probably served to accentuate the sharpness of the line of demarkation between the fused and unfused rocks, and accounts for the sharp contrast to-day visible along the line of contact of upper and lower Archæan.

Relative age of rocks of upper and lower Archæan

9. The normal condition of things along this line of contact proves very clearly that the schists of the upper Archæan, while in a hard and brittle state, were shattered; and that detached fragments became immersed in a magma which at the same time penetrated within the main mass of schists and filled their fissures and crevices. This magma which thus permitted fragments of foreign rock to sink into it, often to great distances from the contact, and which filled the cracks of the overlying schists, crystallized eventually as the Laurentian gneisses; which, therefore, as rocks, must be considered of later age and newer formation than the overlying schists.

Period of yielding to pressure.

10. After such crystallization and final solidification, there appears to have been no further violent disturbance; for while the rocks of the upper Archæan afford abundant evidence in their folded and crumpled condition, in their prevailingly schistose character, and in their microscopic structure, of their having yielded to excessive differential pressure, there is no such evidence in the Laurentian, except locally and to an unimportant extent. The Laurentian gneiss formation, regarded generally, does not appear to have been affected to any notable extent by pressure deformation after it had assumed its present crystalline form of foliated granite or syenite; the foliation being regarded, as above stated, as due to a flow in the magma prior to crystallization, and while crystallization was in progress, but not after the rock was wholly crystalline.

Bedded character of upper Archæan

11. The rocks of the upper Archæan occur in bedded formations, and afford no evidence of having ever been reduced to a fused or plastic state after their deposition.

Coutchiching series.

12. The lower of the two series of the upper Archæan or Coutchiching series is a very voluminous formation of mica schists and felspathic mica schists, or fine grained, grey, evenly laminated gneisses. The latter differ very much in their field appearance and in microscopic

structure from the granite and syenite gneisses of the Laurentian, the constituent grains having a prevailingly rounded or granulitic aspect in thin section. All the rocks of the series are very quartzose, and no other rocks than those mentioned occur in its entire volume, which, in measured sections where the series is at its maximum development, varies from 22,000 to 28,000 feet.

13. It seems entirely probable that this series is of metamorphic derivation from sedimentary strata, deposited in a quiescent epoch, with little or no volcanic disturbance; and that such metamorphism has been largely effected by the upward percolation of heated, watery solutions from the underlying magma upon which the series rested after the fusion of the floor upon which it was deposited. Evidence of the percolation of such waters is seen in the numerous lenses of vein quartz which occupy the partings between the strata in many parts of the series. **Origin of Coutchiching series.**

14. The Keewatin series is also largely metamorphic, but the rocks composing it are mostly of volcanic origin, either as flows or in the pyroclastic state. With these are associated rocks of undoubted erosive sedimentary origin, and others, such as some of the hornblende schists, which, from the extreme metamorphism to which they have been subjected, do not reveal with certainty their original characters; such extreme metamorphism being displayed most prominently at the contact with the irruptive Laurentian gneiss and granite. **Origin of Keewatin series**

15. In a general way, the Keewatin series in the Rainy Lake region is naturally divided into two parts, an upper and lower. The lower part is prevailingly made up of the more basic rocks, such as bedded diabase and hornblende schists, while the upper part is composed rather of acid rocks such as quartz-porphyries and their tuffs and agglomerates with felspathic greywackes and other rocks of distinctly clastic origin. There is, however, no hard and fast line between these two upper and lower parts of the Keewatin, and they are of interest chiefly in shewing the change in the character of volcanic ejectamenta or the sequence of volcanic rocks in the earliest epoch of which we have any record. This sequence of acid after basic rocks accords with the evidence of the sequence of extravasation from the Archæan volcano whose roots are exposed on Bad Vermilion Lake. **Division of Keewatin series.** **Archæan volcano.**

16. The break between the Coutchiching and Keewatin is important, geologically, as indicating a profound change in the conditions of rock formation, the advent of the Keewatin epoch being the beginning of a wide-spread and intense volcanic activity. There is evidence also in the pebble conglomerates at the base of the Keewatin on Rainy Lake and Seine River of an interval of erosion such as is required by the definition of a stratigraphical unconformity. **Break between Coutchiching and Keewatin.**

Relative distribution of upper and lower Archæan.

17. An important discovery has been made in the mapping of the relative distribution of the upper and lower Archæan, whereby it appears that the latter, consisting of Laurentian gneiss and granite, occurs in large, isolated, central areas more or less completely surrounded by the schists of the upper Archæan, the encircling belts anastomosing and forming a continuous mesh work.

The Granites.

Character of granites.

The rocks here considered are of an eminently granitic, non-foliated aspect, usually of a reddish color and a texture that varies from medium to fine grained, although some of them are extremely coarse and partake of the characters of pegmatite. They occur in various parts of the region, irruptive through Laurentian, Keewatin and Coutchiching rocks. Where they have broken through the Laurentian gneisses their age is determinable at once as post-Laurentian and post-Archæan. When, however, they break through the formations of the Keewatin or Coutchiching series, it is a matter of considerable doubt as to whether they are of later age than the Laurentian gneiss, or whether they are portions of the gneiss that have broken through the schist under such conditions that there was developed in them no gneissic foliation. That some of these masses are of such a character is extremely probable, as will be shewn farther on. On account of this difficulty of identifying the age of those granites which cut the Laurentian gneiss with that of those cutting the Keewatin or Coutchiching, and of discriminating between the latter and certain facies of the Laurentian rocks, the granites of the region will be considered under two heads, viz.: (1) Those cutting the Laurentian gneiss, and (2) those cutting the formations of the Keewatin or Coutchiching series.

Age of granites

Classification.

Granites cutting Laurentian Gneiss.

Distribution.

These granites may be studied under their least equivocal and most characteristic conditions of occurrence in an area twenty miles long and five miles in maximum width, at its middle part, which extends across Rainy Lake in an east and west direction from the end of the North-west Bay on the west side, to Macdonald's Inlet on the east. The Laurentian biotite gneisses of this area are intersected by innumerable sporadic masses and irregular ramifying dykes of granite. The largest of these masses do not extend a mile in diameter, so far as observed, while the dykes may have apophyses only a few inches in width. The granite is most plentiful and occurs in largest masses on the shores of the eastern half of North-west Bay. Its characters are very uniform.

It is a reddish, usually fine-grained, biotite granite and has, commonly associated with it, veins of very coarse pegmatite of the character of the so called " contemporary veins."

Relation of granite to Laurentian gneiss.

Although there is the clearest evidence that these granites have cut the gneiss, after the gneiss was in approximately its present condition, yet it seems not improbable that they are more or less intimately associated in age and in origin with the Laurentian gneiss itself, and that they represent simply the up-welling through fissures, of the same magma as that, which, in its more superficial portions, under the influence of fluidal motion had solidified earlier as Laurentian gneiss. But however probable this conjecture may be, the evidence of their having broken through the gneiss after the latter had assumed its present form, is so clear, that we have no option but to classify them as post-Laurentian and post-Archæan. They are always perfectly devoid of foliation, a fact which would seem to indicate that they had solidified in fissures or vents in a comparatively quiescent condition.

Granite of Hanging-stone Point.

One of the largest of these granite masses is that which occupies Hanging-stone Point at the entrance to the North-west Bay. In thin section (840) it appears as a granular aggregate of quartz, orthoclase, microcline, plagioclase and biotite, the last very largely altered to epidote and chlorite. Apatite in long needles is included in all of these minerals. The felspars are in some instances quite fresh, while in others they are charged with kaolin, epidote and muscovite. The quartz is full of liquid inclusions with dancing bubbles. Another specimen (922) from a similar but smaller mass at the west end of the bay, near Hope Portage, is almost identical with the one from Hanging-stone Point. The only difference to be noted is that the biotite, as à rule, is fresher, shewing very beautifully between crossed nicols its characteristic bird's-eye-maple shimmer, though sometimes it is bleached colorless. Both quartz and felspar shew undulatory extinctions.

Hope Portage granite.

Granite near Squall Point.

Of the granites associated with the Laurentian gneisses in other portions of the region, only one has been microscopically examined. It is a fine-grained, purplish, hornblende granite, which interrupts the gneiss on one of the islands off the S.E. corner of Squall Point. Only a small patch of it was seen, and the actual contact with the gneiss was not observed. A thin section (665) shews it to be made up of a granular aggregate of orthoclase, plagioclase, quartz and hornblende, with some accessory biotite, magnetite and leucoxene. A little apatite is also, as usual, present. The quartz and felspar shew a crude granophyre structure, and the quartz is besides observed to occur commonly in spherical blebs included in the felspar. The quartz contains numerous inclusions of rod-like microlites. The most prominent constituent after the felspar is the hornblende. This has sometimes a

roughly radiating, fibrous structure, though usually quite compact, and in basal sections shews the usual prismatic cleavage. An occasional plate of biotite, probably original, is observable, while there is a good deal more that has been formed as an alteration product of the hornblende with which it is closely associated, and a little that has been secondarily developed around grains of magnetite.

Bat Lake granite.

On the Little Canoe River route from Rainy Lake to Manitou Lake a boss of red, medium textured granite is crossed, the north and south diameter of which is about seven miles. The boss is apparently irruptive through the more or less syenitic, coarse-grained, Laurentian gneisses, and extends from the northern portion of Bat Lake to the south end of Respite Lake. The contact of the granite with the gneiss is more closely observable on its southern confines than on its northern, and at the south end of Respite Lake the gneiss is traversed by dykes of the granite. The rock is composed of a red orthoclase, quartz and biotite, the latter being often replaced by hornblende, so as to give rise to a hornblende-granite. On Bat Lake the line of contact can be traced approximately, as mapped, without, however, affording any satisfactory exposures of the actual juxtaposition of the two rocks. The granite is well exposed on Bat Lake and Bat Creek, the latter being a sluggish stream in a gorge, flanked on either side by precipitous granite hills. On the shores of Bend Lake the facies of the rock is that of a hornblende granite. No specimens from these granites have been examined microscopically. A similar mass of red granite projecting through an area of Laurentian gneisses is observable on the shores of Spawn Inlet, and has a length in a north and south direction of at least three miles and a half.

Other granites cutting Laurentian.

The only other granitic masses cutting the Laurentian gneisses in the region mapped are small and unimportant, and are usually rather of the character of a plexus of dykes than simple irruptive bosses. A few of these are, however, deserving of brief mention. The gneiss on the shores Blue-beard Lake is interrupted by a mass of red granite, which occupies the west shore of the lake for three-quarters of a mile at the north end, and the east shore for about one-eighth of a mile as mapped.

At the north end of Heron Lake, a number of dykes cut the gneiss in different directions.

On the south-east shores of Big Turtle Lake the gneiss is similarily traversed by dykes, and small, irregular masses of red granite, so much so that in some places of limited extent the granite predominates over the gneiss.

Granites cutting the Keewatin and Coutchiching.

On Pickerel Lake, Manitou route, two apparently distinct bosses of granite occur, one on either side of the lake, cutting the Keewatin rocks. **Two granite bosses on Pickerel Lake.** That on the west side is a flesh-red, coarse-textured granite, which under the microscope (1008) is seen to be made up of orthoclase, microcline and plagioclase, with epidote and chlorite in nests replacing the biotite, a little of which, however, still remains. Some of the orthoclase is idiomorphic, being of earlier generation than the rest of constituents, though it does not differ from them in size sufficiently to present a marked porphyritic aspect. The felspars are full of inclusions of microlites and needles of apatite. Beautiful, double-wedged sphenes are common, often in close association with an opaque substance, brownish in reflected light, as if secondarily derived from it.

The extent of this mass of granite is only known from its exposure **Extent of boss on W. side.** on the shores of Pickerel Lake. The rocks through which it is intrusive are partly volcanic and partly clastic rocks, those on the south side of the boss being felsitic schists (schistose quartz-porphyries) and on the north side, greenish-gray, schistose, clastic rocks. The actual contact on either side was not observed, although it could be located very closely.

The granite from the east side of Pickerel Lake presents on its **Boss on E. side.** margin the facies of a porphyry, which, under the microscope (1032) is seen to consist of a fine-grained, ground mass of quartz and felspar in which are imbedded large crystals of orthoclase, twinned according to the Carlsbad law, and finely laminated plagioclase, both comparatively fresh. Biotite generally much decomposed occurs in ragged patches and pyrite partially changed to limonite is occasionally observed.

The limits of this boss have been fairly well determined, from the **Its limits.** fact that it occupies a portion of a peninsula on the greater part of whose shores the rocks are well exposed. It is apparently an oval mass whose long diameter, one and one-eight miles, has a N.E. and S.W. trend and the short one, three-quarters of a mile, a N.W. and S.E. The rocks through which it protrudes are mostly felsitic grauwacke, and conglomerate on the south and west side, and finer schistose or slaty clastic rocks on the north.

On the shores of the south-west side of Bad Vermilion Lake and on **Granite of Bad Vermilion Lake** Bad Vermilion River there occurs, as is represented on the map, a boss of granite between three and four miles in diameter. This granite is peculiarily interesting from the fact of its intimate association with a still larger mass of saussurite gabbro. The granite is, for the most part, unusually acid or quartzose, while the gabbro, being made up

mostly of an altered lime felspar, anorthite, with but a small proportion of the foliated pyroxenic constituent, is among the most basic rocks with which we have to deal. This granite and gabbro are intimately associated, the latter surrounding the main mass of the former as a zone or collar. A smaller area of granite lies to the south beyond the zone of gabbro which encircles the main granite mass. Portions of this, in places, exhibit an indistinct sort of foliation, and hornblende occasionally replaces the biotite. The geological relations of this granite and gabbro have already been discussed in the account of the section K-L across this part of the Keewatin belt.

Bad Vermilion River.

A few specimens of the granite have been examined microscopically. One from the second falls of the Bad Vermilion River, appears under the microscope (2150) as a simple granular aggregate of quartz, cloudy orthoclase and plagioclase. The biotite is never abundant, and is almost all changed to chlorite and epidote. The quartz contains fine dusty inclusions and liquid inclusions with bubbles.

Specimens.

Another specimen (48), from the larger of the two masses into which the granite is divided by a band of gabbro, taken from the extreme south of Bad Vermilion Lake, differs from this in having quartz in large, rounded blebs, imbedded in the granular aggregate of quartz, felspar and biotite, which forms the base of the rock. These blebs of quartz shew a well marked ecto-peripheral rim, composed mostly of small, brightly polarizing needles, sometimes arranged perpendicularly to the outline of the quartz, and sometimes arranged parallel to it or interwoven in a felt work. The quartz includes microlites of apatite, rutile and zircon; and rutile is common as an inclusion in the biotite which is sometimes bleached, or altered to chlorite; calcite is present as an alteration product of the felspars which are more or less cloudy.

At the S.W. end of Bad Vermilion Lake this granite is in thin section (50) a granular aggregate of quartz, orthoclase, microcline and plagioclase, with idiomorphic apatite, zircon and sphene. The quartz is full of liquid inclusions with moving bubbles. The felspars are somewhat cloudy with kaolin, muscovite, etc.

Boss of granite on Pipestone Lake.

On the north-west side of Pipestone Lake, near its lower end, a boss of granite breaks through the Keewatin schists and is entirely surrounded by them. The granite is exposed for three-quarters of a mile on the shore of the Pipestone Lake, but the greatest diameter of the boss is probably a mile or over. Although detached from the great area of Laurentian gneiss and granite which extends to the westward of Kishkutena ridge by the Keewatin schists which constitute the ridge, it is probably in geological continuity with the gneiss and granite. It is quite devoid of foliation, but not more so than many portions of the Laurentian gneiss on Kishkutena Lake. It is, therefore,

regarded as Laurentian and is described petrographically with the Laurentian gneisses.

A large number of sporadic masses of granite and gneiss cut the rocks of the Coutchiching series in the south-east arm of Rainy Lake. Some of these are distinctly gneissic and are indistinguishable from the ordinary Laurentian gneiss of the region. Others are of the character of very coarse non-foliated granites or pegmatites. These masses are usually of small extent and break through the schists in the most irregular manner. On the United States side of the lake, however, the peninsula between Rainy Lake and Nemeukan Lake appears to be largely occupied by the coarser variety of these granites. Most of them from their analogy with the Laurentian gneisses should probably be placed with the latter, although it is possible that some of them may be correlated in age with the post-Laurentian granites. Their distribution is shown on the map. None have been microscopically examined. **Granites cutting the Coutchiching.**

Post-Archæan Diabase Traps.

These are the youngest of the crystalline rocks with which we have to deal. Their occurrence is one of the most interesting of the geological features of the field we are considering. The chief questions of interest arising from a consideration of these rocks may be stated to be :—1. Their relations *in space* to other rocks—mode of occurrence. 2. Their relations in time of formation to that of other rocks, as inferred from such mode of occurrence. 3. The physical conditions under which they finally solidified as rocks. 4. Their geographical distribution. 5. Their petrographical character, comprising their mineralogical composition, structure and metamorphism. Upon these various heads, which include most of the interest attached to any formation, we have more precise and definite information than can be cited with respect to perhaps any other geological formation in this region. **Questions of interest.**

By far the greater number of the occurrences of these post-Archæan traps are of the nature of dykes with sharply defined, approximately parallel, confining walls. Occasionally they are found in more diffuse masses with less regular boundaries, without, however, losing their dyke-like characters, if we consider, as the essential feature of a dyke-rock, the fact of its having solidified from a magma within a fissure in pre-existing rocks, whether the walls of such fissure be comparatively close and parallel, or widely separated and of irregular contour. These traps may then, for the most part, be referred to as occurring in dykes. **Mode of occurrence of dykes.**

Strike of dykes. The strike of these dykes is commonly transverse to the strike of the gneisses, schists and other rocks of the region. And they are always, when bounded by parallel walls, in a more or less vertical attitude. The fissure walls are remarkably sharp and are brecciated only to a very limited extent. It is only occasionally that fragments of the country rock are found imbedded in the dyke, and when this is the case it is often possible to trace the fragment to the place from which it has been detached, as has been noted in the case of the dyke crossing Thompson Island, Lake of the Woods.* Even rarer than inclusions of country rock in the dyke is the occurrence of lateral apophyses penetrating the country rock. In the few instances where these have been noted, they usually run out obliquely from the main dyke at a small angle, and are very insignificant in size compared with the parent dyke. An inspection of the occurrence of any of these dykes leaves no room for doubt, but that the fissures that have been filled with dyke matter were made after the rocks of the region had been tilted into their present attitude or had solidified in approximately their present form. They traverse indifferently all the other rock formations of the region, and pass from one to another transverse to the line of their contact. The few inclusions that have been caught up by the dykes are identical, in every respect, with the adjacent country rock. Local metamorphism along the line of contact has not been developed so as to be macroscopically apparent, a fact probably due to the generally highly crystalline state in which the rocks were before the molten dyke matter came in contact with them. It is very probable, however, that a microscopic study of the country rock near the contact would shew that chemical and physical changes had been induced. There is no evidence whatever in the dykes themselves or in their relations to the rocks they cut, of their having been subjected to those forces of upheaval, folding and deformation that have so profoundly affected the other rocks. They have been practically undisturbed since the time of their solidification. The dykes which are contained by parallel walls have a generally uniform width of from about 60 to 150 feet. Their strike is, for the most part, in a remarkably constant direction, being N.W. and S.E. There are, however, some exceptions to this rule as will be noted below. Their continuity along the same straight line for great distances across country, not as the same dyke, perhaps, but as a prevailing line of fissure, is one of the most interesting features of these dykes, as will appear in the discussion of their geographical distribution.

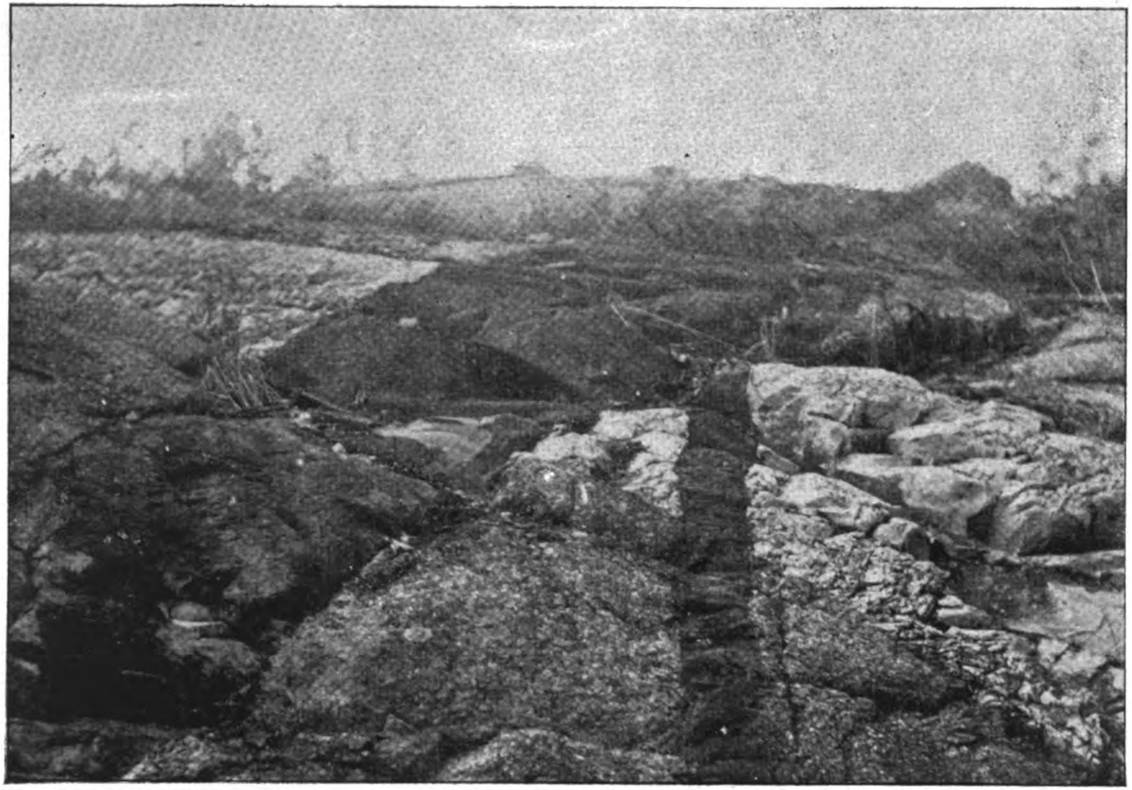
Lateral apophyses.

Age of dykes.

Width of dykes.

A constant character of all these dykes is the very marked differentiation observable in the texture of the rock as one passes from the

* v. Annual Report, 1885, p. 121 c c.



A. C. LAWSON, PHOTO., 1887. G. E. DESBARATS & SON, ENGRAVERS & PRINTERS, MONTREAL.

Diabase dyke, with lateral off-shoot, cutting Laurentian gneiss through which runs an earlier dyke (lightest colored portion) of felsite or microgranite. Rainy River, opposite the east end of the town of Fort Frances or Alberton.

Differentiation in texture.

contact with the country rock on either side towards the central portion of the dyke. At the immediate contact with the fissure walls, the dyke rock is, in every case observed, a very compact, greenish, black rock, either entirely aphanitic, or made up of an aphanitic base in which are imbedded minute, glistening, porphyritic crystals. A little distance away from the contact, often only a few inches, the rock rapidly, but by insensible gradations, assumes a granular aspect, being made up entirely of minerals which appear to the unaided eye to be distinct crystals, although very minute. This fine-grained rock passes gradually into a coarse-grained, mottled, dark grey rock in the middle of the dyke where the greenish-white felspar, the lustrous black augite, and the metallic-grey magnetite may be distinguished at a glance. This transition in the texture of the rock appears to be practically the same in all the dykes; and a specimen from the middle of a large dyke does not appear to be of coarser texture than that from the middle of a small dyke. Hence the transition in a small dyke must be more rapid than in a large dyke.

Differentiation due to variation in rate of cooling.

The texture of the rock being a function of its distance from the containing walls, it is inferred that it is also a function of the rate of cooling and solidification. If this inference be just, and it is of wide acceptance among geologists in analogous cases, it has its bearing upon the general question of the relation of rock structure and rock texture to conditions of solidification. Important investigations have of recent years been made upon this subject, particularly by Stelzner,* Judd,† Hague and Iddings,‡ and Lotti§. The general tendency of these investigations has been to establish the intimate relationships existing between the structure of igneous rocks and the *pressure* under which they have cooled. In the case of the dykes which we have been considering, however, the differentiation in texture and structure is not a function of pressure. For, in the horizontal plane, which the present surface affords us, we must conceive the pressure in the liquid mass, now represented by the dyke, to have been practically uniform and the same near the walls of the fissure as in the middle of the mass. We have the same magma cooling at the same depth and under the same pressure, presenting a very rapid differentiation in structure and texture, in a comparatively short space, so that we are forced to admit that the structure and texture of these rocks is a function of the rate of cooling quite independent of the pressure. This conclusion does not, of course, preclude the possibility that, under a *varying* pressure, a

Variation in pressure *vs.* variation in rate of cooling.

* Beiträge zur Geolog. u. Palæont. der Argentinisshen Rebublik. 1885.

† Gabbros, Dolerites and Basalts of Tertiary age in Scotland and Ireland. Q. J. G. S., Vol. XLII., 1886.

‡ Development of crystallization in the igneous rocks of Washoe. Bull. U. S. Geol. Survey, No. 17, 1885.

§ Paragone fra la roccie ofiolitiche italiane e le roccie basiche pure terziare della Scozia e dell' Irlanda (Boll. d. Com. geol. ital., 1886, 93).

differentiation in structure might be induced of an entirely different order to that which is a function of the rate of cooling simply. It would appear that no attempt has yet been made to discriminate between that differentiation of structure which is due to difference in rate of cooling, and that which may be due to varying pressure simply, or that which may result from a combination of these two varying influences.

Prominence of dykes.

These dykes stand out more or less prominently from the rocks they cut, their steeply rounded or domed glaciated surfaces contrasting strongly with the more gently inclined *roches moutonnées* of the schists and gneisses. On the smooth glaciated surfaces of the dykes there is sometimes observed a peculiar pitting arranged in remarkably even and straight, uniformly spaced lines which run across the dyke transverse to its strike. These lines seemed to correspond to the surface limits of vertical structural planes of some sort, though what the real nature of these planes is, I have not been able to discover.

Weathering.

The aërially weathered surfaces of the dykes assume usually brownish tints, and are rougher than those surfaces below high-water mark, which are of a black color, and retain a smooth, fresh aspect.

Dykes on Lake of the Woods.

On the Lake of the Woods it has been observed that a line of dyke filled fissures extends in a N.W. and S.E. direction from the vicinity of Rat Portage to the E. side of White-fish Bay near the S.E. corner of the area embraced in the Lake of the Woods sheet. The intervals at which these dykes have been observed on the northern part of the Lake of the Woods are probably much greater than the actual occurrences of them warrant, as, at the time of the geological examination of these shores, they were not particularly looked for, and their characters were less familiar than they are now, and less easily distinguished from those of the more massive altered diabases of the Keewatin series. However, there is enough evidence to indicate a well marked line of fissure. The dyke which cuts the S.W. end of Scotty Island is very probably identical with that which traverses Thomson Island from N.N.W. to S.S.E.; and this, together with the dyke which cuts the Keewatin schists on the main shore S.S.E. of Yellow-girl Point appears to be in the north-westward projection of the remarkable line of dykes which my assistant, Mr. A. E. Barlow, traced across White-fish Bay in 1885, at intervals, for sixteen miles, with a strike of 140°. If we follow this line south-eastward we find these dyke-filled fissures continued at intervals, as far as our explorations have gone, to the south side of Rainy Lake on the International Boundary. The first of this linear series of dykes is one which cuts the green schists of the south side of Crow Lake a little over a mile to the N.E. of Crow portage. The next observed crops out on Clear-water Lake just where the 49th

Line of dyke-filled fissures for 100 miles.

parallel intersects the N.W. shore of the lake. In nearly the same line a large dyke crosses Jack-fish Lake less than a mile east of Totem Point. Still further to the S.E. on the shores of the North-west Bay of Rainy Lake there is another at the west side of the entrance to Brown Inlet. At the north-east corner of Stanjikoming Bay and on the north shore of the adjoining Shoe Bay, there is a group of three parallel dykes not far separated, all having a common strike of N.W. and S.E. The most easterly of these appears to be the strongest and probably represents the dominant fissure. On the north shore of Shoe Bay it is between 60 and 70 feet wide, and occupies two small islands which lie off shore in the mouth of the bay. It is probably identical with the dyke which cuts the gneiss on the N.E. side of Home-stretch Island, and occupies the southern extremity of Risky Island. About a mile and a-quarter to the south-east of the latter, in almost the same line, we have a large dyke occupying the east half of Memento Island, crossing Gash Point, and appearing again on Lobstick Island and the adjacent small islands. On the south side of Rainy Lake in the line of the strike of the dykes of Shoe Bay and Gash Point, two large well defined dykes have been observed which have a N.W. and S.E. strike but which are not quite parallel, being convergent at a small angle towards the south. The more easterly of these is more nearly in a line with the Gash Point dyke than the other. It traverses Stop and Grassy Islands, and some of the adjacent smaller islands, and has been traced for one mile and three-quarters from its most northern exposure to where it cuts the rocks of the south main shore. The other more westerly dyke traverses Medouganak Point and crosses the mouth of Rat-root Bay, being observable on both shores.

Dykes between Shoe Bay and S. shore.

I have thus sketched briefly the distribution of a series of dykes which, in a very remarkable linear arrangement, and all with a common strike, extend from the north end of the Lake of the Woods to the south shore of Rainy Lake, a distance of 100 miles. The line of their occurrence has a bearing of 140° to 145°. The fissures of which they are *prima facie* evidence, whether they be absolutely continuous or be made up of a series of ruptures with intervening planes of strain, have probably played an important part in the post-Archæan earth movements which have affected the region. It is difficult to positively assert that any profound faulting has occurred along this line, since there is little direct evidence to warrant such an assertion. That it is a line of fault, however, seems extremely probable, and it is worthy of note that the whole rocky surface of the country to the S.W. of this line of dykes and to the south of the 49th parallel, is on a level distinctly lower than that of the country to the N.E. of that line, being covered with the flat-bedded, low-lying, post-glacial deposits through

Line of fissure, and probable faulting.

which Rainy River has cut its way. Although the linear arrangement of these dykes is very marked, it does not follow that the fissure was confined to any single line. Indeed, as has been noted, the dykes occur in triplicate and duplicate; but, in these instances, the dykes have been so near together as to leave no doubt as to their close relationship, all being in the same linear area. There are a few dykes, however, which have been observed to lie a little out of the line of fissure, as above sketched, and although they have the same strike, are to be regarded rather as belonging to parallel but subordinate and less pronounced fissure lines than the main line. One of these dykes occurs on the east side of Clear-water Lake, three miles and a-half south of the 49th parallel. Another crosses the south shore of Pipestone Lake one mile west of Stone-dam Portage. In this category also may be classed the dyke which crops out on the United States side of Rainy River opposite the east end of the town plot of Fort Frances. (*v.* Plate VII.)

Parallel fissures.

Line of dykes from Shoal Lake to Little Grassy River.

The dykes enumerated do not comprise all that have been observed. In the south part of the Lake of the Woods a line of post-Archæan irruption has been noted and mapped on a string of small islands extending some eight miles N.W. from the N.W. point of Big Island. This irruption does not appear to be a simple parallel-walled dyke, but seems in places to have a very considerable width, and its exact distribution cannot be determined on account of its occurrence on a number of small islands. The arrangement of these islands in a line which runs N.W. and S.E. is eminently suggestive of the strike of the longitudinal axis of the irruption. The contact of the irrupted trap has, moreover, been observed on two of the islands, viz., on Massacre Island and on a small island two miles W.N.W. of the north end of Bear Island, and in each of these cases the strike of the fissure wall is N.W. and S.E., and all the conditions of contact are identical with those observed in dykes of more limited dimensions and contained within observable parallel walls. The north-westward projection of the line in which these trap islands lie, passes through a small boss of trap that projects through the sand at the south end of Shoal Lake. And with this is probably associated a mass of trap which cuts the schists on a small island off the west shore of Shoal Lake between Berry Point and Calm Bay.

The south-eastward projection takes in a dyke which cuts the gneiss on the west side of Bigsby Island near its south end, and another which occupies part of a small island opposite the mouth of Little Grassy River. Thus we have again sketched for us by the occurrence of a line of dykes, another line of fissure extending for over forty-five miles in a general N.W. and S.E. direction, and again the surface of the country is lower to the south-west of this line than it is

to the north-east. This line is not strictly parallel to the White-fish Bay line of fissure, but varies from parallelism only by a very small angle, the two lines being convergent towards the south-east at an angle of between 5° and 10°. Assuming their continuity across the state of Minnesota, they would meet near the head of Lake Superior. The line of fissure indicated above as extending from the bottom of Shoal Lake to the mouth of Little Grassy River appears to be distinctly traceable for the distance of forty-five miles. There is evidence, however, of its much greater extension to the S.E. The country to the S.E. of the mouth of Little Grassy River is covered with post-glacial formations, and no occurrence of dykes has been noted along this line for thirty-five miles. After this interval, however, we again meet with them in great strength on Rainy River. The Manitou Rapid on Rainy River flows over a large dyke, whose strike appears to be N.W. and S.E. The actual contact with the enclosing rocks is not exposed, but a distinct gradation from a fine to a coarse texture can be observed, indicating that the containing walls of the dyke cannot be far distant from the part with the finest texture; and the dyke presents a distinct ridge at right angles to the stream which is taken to be its strike. For three miles north from the river this trap can be traced through the bush at intervals on the Indian Reserve. It seems to lose its dyke-like characters to the northward, and to merge into a rather extensive boss of uniformly coarse gabbro. About six miles further up Rainy River, above Manitou Rapid, there are two other dykes which may perhaps be classed with that at the rapid, and so be considered as belonging to the same line of fissure. They both have a strike of from N.W. and S.E. to N. and S. One of these occurs on the American shore projecting through the post-glacial formations as a prominent bluff, and cuts through green hornblende schists. The other occurs on the Canadian side, about one mile and a-half from the river at the back of Mr. Lutterel's farm. Like the first it projects boldly through the post-glacial deposits with a width of about 150 feet without, however, shewing the rock which it traverses. On either side of the middle part of the exposure the rock becomes finer-grained towards the sides, so that it may safely be inferred that the exposure represents very nearly the width of the dyke, although the contact is concealed. The coarser portions of the dyke shew, in places, a very distinctly foliated, possibly a "flowed" structure. Thus if these dykes on Rainy River be assumed to be part of the same system of fissuring as that traced from Shoal Lake to Little Grassy River, and they are approximately in the same line, that system will have a linear extent of over eighty miles, and is then comparable, in its minimum length,*

Convergence of two lines of dykes.

Dykes on Rainy River.

Foliated structure in dyke.

* Of course either of these lines of fissure may extend to the N.W. and S.E. beyond the limits of the field of exploration.

with that of the White-fish Bay system of fissuring. Two other trap dykes have been observed on the river which do not fall into line with any others. One of these crops out on the south side of the river one mile below the foot of the Longue Sault. The other crosses the river in a N.W. and S.E. direction, and causes a slight rapid in the stream, about half a mile above the mouth of Rapid River. Neither of these is sufficiently exposed to afford positive evidence of their being dykes, and that they are so, is inferred chiefly from the similarity of the rock to that of the other dykes of the region. One other dyke remains to be noticed and that is unique in having a strike of N.E. and S. W. It occurs on a small island two miles and three quarters W.N.W. of Halleluiah Point near the mouth of Seine Bay, with a width of sixty feet cutting the Bad Vermilion Lake saussurite-gabbro formation.

Other dykes.

Petrographical characters.

The petrographical characters of these dykes have only received a preliminary study so that no exhaustive statement regarding them can be made. A few notes on the microscopic features of some of them which have already been published elsewhere,* are, however, incorporated here, so that taken with the foregoing description of their field occurrence they may make the general account of these dykes as complete as possible to date.

Jack-fish Lake dyke.

One of the most characteristic of these dykes traverses the coarse granitoid gneiss of the west arm of Jack-fish Lake, which lies to the north-west of Rainy Lake. Its width is 135 feet and its contact with the country rock is well exposed as a sharp line. From a macroscopic examination, the gneiss does not appear to have been altered perceptibly towards the contact. Specimens for microscopic examination were taken from different parts of the dyke, viz., at sixty feet, twenty feet, and six feet from the contact, and at the contact. At sixty feet from the contact, the rock is a coarse-grained, mottled grey rock, in which dirty white felspar and black pyroxene are the prominent constituents. Under the microscope it presents the characters of a coarse-grained, comparatively fresh diabase. Augite of a pale mauve tinted grey color is abundant, and often occurs in masses that fill the field of the microscope when low powers are used. Sometimes these plates of augite are individual crystals. For the most part, however, they are not single individuals. When examined between crossed nicols the plate of augite is seen at once to be resolved into an intimately interlocking mosaic of irregularly shaped grains of diverse optical orientation. In ordinary light the boundaries between the different members of these "polysomatic"† masses of augite are traceable only with difficulty and uncertainty. There is no interstitial

Rock at 60' from contact.

"Polysomatic" augite.

* Proceedings Canadian Institute, 1887.

† Adapted from Tschermak's use of this word as applied to a similar structure in the olivine of certain meteorites.—v. Die Mikr. Beschaff. der Meteor. Stuttgart, 1885.

matter whatever, the different grains being as intimately associated as in the case of interpenetration twins of felspar. That they are not twins is shown by the fact that there are often as many as half a dozen grains all of different orientation thus combined in the same mass. The cleavage, by its lack of continuity over the field, of course, indicates a difference of orientation in different parts of it, but the cleavage traces are not strongly marked, and attention is only directed to the discordance of the cleavage after the polysomatic character of the mass has been rendered prominent by the analyser of the microscope. This polysomatic structure of augite does not appear to be common. Rosenbusch does not mention it in his last comprehensive summary of the present state of petrographical knowledge.* The nearest approach to this structure that is at all well known is the polysomatic character of some chondri of olivine in certain meteorites such as are figured by Tschermak† and Wadsworth.‡ Olivine in a similar condition in terrestrial rocks has recently been described and figured by Renard in specimens from Kerguelen Island in the Indian Ocean.§ The polysomatic structure in augite is not so well known. Renard notes that the augites of the felspathic basalt of Heard Island, Indian Ocean, are grouped together at certain points,|| and again in the same rocks at Marion Island that the augite is characterised by a tendency to form groups of individuals having their vertical axes parallel.** Teall mentions "Granular Aggregates" of augite in the Hett and the High Green dykes in the north of England.†† Some of these appear from the figures given to be aggregates of grains of augite not in close juxtaposition with an interstitial base, although that figured in Plate xii, Fig 5, would seem to be a polysomatic augite, and if so is the only strictly parallel instance that I can find of this structure so common in this dyke and in others of the region.

Analogies.

The augite is generally altered to hornblende at its periphery and occasionally the latter mineral entirely replaces the former. The process of alteration does not appear to proceed along the almost or quite imperceptible lines of demarkation between the different individuals of the polysomatic augite, but extends from the periphery of the mass as a whole in towards its centre.

Alteration of augite.

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* Mikr. Phys. der Mineralien und Gesteine Stuttgart, 1886.

† Die Mikr. Beschaff. der Meteor. Stuttgart, 1885, Taf. xv. Fig. 1 and 2.

‡ Lithological Studies, Mem. Mus. Comp. Zool. Harvard, Vol. x., pl. 1.

§ Notice sur la geologie de l'ile de Kerguelen, Bul. Mus. Roy. Hist. Nat. Belgique, Tome IV. No. 4., p. 233, fig. 1, pl. v.

|| Notice sur les roches de l'ile Heard. Bull. Mus. Roy. Hist. Nat. Belgique, 1883, 8 p. 26.

** Notice sur les roches de l'ile Marion. Ibid. p. 250.

†† Petrographical Notes on some north of England Dykes, Q. J. G. S., 1884, 158. p. 2.9 and 242.

Plagioclase.

The plagioclase appears in two general forms: a rather stout or tabular form, which is the larger and usually the more cloudy with decomposition products, and a small long lath-shaped felspar which appears quite fresh, and in which the polysynthetic lamellæ are much more distinct than in the former.

Accessory minerals.

Magnetite occurs in irregularly bounded masses or is disseminated, often quite thickly, through the augite as inclusions of dusty or finely granular aspect. Pyrite also occurs and is discernable macroscopically. Apatite is seen in occasionally colorless hexagonal sections and in slender prisms with rounded terminations. Water-clear quartz, with inclusions of apatite microlites and liquid inclusions with dancing bubbles, forms a considerable proportion of the mineral constituents of the rock and is characterized by having a common orientation for isolated sections over a wide area of the microscopic field, as in the micropegmatite structure. A few colorless garnets are also present. The rock, such being its characters, may be classed as a uralitic quartz-diabase.

Rock at 20' from contact.

At twenty feet from the contact the rock is very similar to that at sixty feet, but is much less coarse in texture. It differs from the latter in mineralogical composition in the fact that there is present a number of white or colorless garnets, all perfectly isotropic. They have a well defined border, indicative of a high index of refraction and perceptibly rough surface. Their shape is for the most part rounded, or, when rectilinear outlines are observable, they are hexagonal sections of the rhombic dodechedron. The larger grains have a curved parting which may be demarkation lines between different individuals. The treatment of the slide with hydrochloric acid, cold or hot, leaves them unaffected. The occurrence of garnets in basic dykes is by no means unique. They are, however, regarded as a product of contact metamorphism within the dyke. Speaking of the "Iron District of Lake Superior," Wadsworth says: "Most of the 'diorites' (uralitic diabases) here (at Republic Mt) contain garnets, this mineral being found principally along the edge of the intrusion while the centre was nearly if not entirely free from it. The schist in like manner near the 'diorite' frequently contains garnets, both rocks appearing to have mutually reacted upon each other."* The garnets in the Jack-fish Lake dyke do not appear to be a product of contact metamorphism, since they are found in the middle of the dyke and very much more abundantly at twenty feet from the contact than at six feet from it, or immediately at the contact, where their presence has not been detected. Beyond the abundance of garnets, the dyke at twenty feet has the same characters as at sixty feet. The polysomatic structure of the augite is pronounced.

Garnets in dykes.

* Notes on the Geol. of the Iron and Copper Districts of Lake Superior. Bull. Mus. Comp. Zool. Harvard, 1880, pp. 45, 46, 47.

At six feet from the contact the rock is fine-grained and the ophitic structure of typical diabase is much more characteristically developed than in the coarser grained parts of the dyke. In this part of the dyke there is first observed a differentiation of the rock into constituents of different periods of crystallization, the order being first plagioclase in more or less idiomorphic,* lath-shaped individuals lying in all positions, then augite generally allotriomorphic,* sometimes hypidiomorphic,* and finally a base or matrix of both these minerals in a very much more finely crystalline state, together with magnetite. The structure of the base is rather obscure, the chloritic substance usually present in diabase rocks being more prominent here than in the coarser grained part of the dyke where it is almost, or perhaps entirely, wanting. Quartz is present but in smaller quantities than in the coarser grained portions of the dyke. The augite occurs both in simple individuals and in polysomatic masses. The uralitization of the augite, which is generally observable, is much more pronounced in the irregularly bounded polysomatic masses than in the simple allotriomorphic development of the same mineral. A few garnets are present as inclusions in the felspar, but were not identified with certainty. In this respect this portion of the dyke differs markedly from the more central portions examined. The most interesting constituent of this portion of the dyke remains, however, to be mentioned. It is the non-pleochroic, colorless, rhombic pyroxene, enstatite; it occurs in idiomorphic development showing the characteristic obtuse domes in some of the sections. It shows regular cleavage parallel to ∞ P (110), upon which the angle of extinction is zero, and characteristic cross parting, along which partial alteration of the mineral to bastite or serpentine is apparent. This enstatite is not abundant, and plays the rôle of an accessory mineral. Its occurrence in a rock of well marked diabase structure is interesting. Rosenbusch remarks that it is present in only a few diabases which have a gabbro-like structure,† and Teall has recorded the occurrence of the allied rhombic pyroxene bronzite in the Whin-Sill of the north of England as an accessory.‡ Enstatite also occurs in a variety of the allied rock, diabase porphyrite, from Schaumberge, which has been described by Laspeyres and Streng under the name of Palatinite. This enstatite was not observed in the coarser parts of the dyke but occurs, as will be noted, in the still finer grained diabase at the contact.

Rock at 6′ from contact.

Enstatite.

At the immediate contact the dyke assumes macroscopically the characters of a very compact, greyish-black, aphanitic rock in which

Rock at contact.

* Terms introduced by Rosenbusch. Cf. op. cit. p. 11.
† Mik. Phys. der Massigen Gestine, 2nd Ed., 1886, p. 188.
‡ Q. J. G. S., 1884, p. 652.

can be occasionally detected minute glistening facets of porphyritic crystals. With low powers of the microscope the matrix is not resolvable, but appears as a uniformly yellowish to greenish-grey ground thickly dotted with grains of magnetite. Under the higher powers this is seen to be made up, in addition to magnetite, of a fine felt-work of lath-shaped crystals of plagioclase imbedded in hazy, somewhat yellowish green flocculent chloritic substance derived presumably from the alteration of the augite, since that mineral cannot, with certainty, be identified in the base. The porphyritic character of this part of the dyke is well marked, though the imbedded crystals are small. These are augite in small irregular polysomatic masses, with a hazy margin or fringe of greenish decomposition products, long lath-shaped plagioclase and occasionally stouter broken fragments. Besides these are porphyritic crystals of enstatite much more altered and less plentiful than at six feet from the contact. Neither quartz nor garnet are observable in the contact rock.

Porphyritic character.

Points of interest.

Considering then the dyke with reference to its variation in structure and mineral composition, the points of interest to be noted are: the passage of the coarse grained central portions of the dyke to the compact aphanitic rock at the contact; the absence of porphyritic structure in the middle of the dyke as contrasted with the well marked development of the same as the rock becomes finer grained towards the dyke walls; the absence of the characteristic chloritic substance of diabase in the centre of the dyke, and its abundance towards the contact; the presence of quartz in greater quantity in the coarse grained middle portions than at the sides; the presence of garnets in the coarsest parts of the dyke, their abundance in the medium grained parts, and their rarity or total absence in the neighborhood of the contact; the presence of the rhombic pyroxene enstatite in typical idiomorphic porphyritic crystals in the fine grained parts near the contact, and its absence in the coarser central parts; the diminution in size of the porphyritic crystals near the contact in co-extension with the increasing fineness of the ground mass; and finally the "polysomatic" structure common to the augite throughout the dyke.

Continuation of dyke.

Three-quarters of a mile from where the specimens whose characters have just been given were collected, there occurs, on the opposite side of the bay in the line of the strike of the dyke, another exposure of the same dyke. On the islands of the bay which lie intermediate between these two localities, the outcrop of the dyke is observable, so that there is no doubt of their both being exposures of the same dyke. The rock here was not studied in so great detail as at the last exposure. The specimens taken were of the same grade of coarseness as those taken at twenty feet from the contact on the north side of the

bay. The felspars are more decomposed, and the twinning lamellæ often obscure, and the small quantity of quartz which is associated with them appears to be of secondary origin; whereas the origin of the quartz noted in the same dyke on the north side of the bay seemed much more problematic. In the latter case the common micropegmatic character of the quartz and the occurrence in it of needles of apatite, which in no way differ from those in the felspar, together with the not infrequent occurrence of one individual of apatite partially included in quartz and partially in an adjacent felspar, would argue for the primary character of the quartz. The augite in the dyke on the south side of the bay resembles that already described, occurring both in simple individuals and in polysomatic masses. It is largely altered to uralite. Titanic iron with its alteration product leucoxene shows characteristic barred structure of the cleavage traces parallel to the planes of the rhombohedron. The leucoxene is frequently accompanied by a margin more or less extensive, of secondary brown mica. Apatite is present in comparative abundance. Chlorite occurs in vaguely defined masses and the garnets which, as before, are present, are associated with it. Characters of other specimens.

On the south-east shore of Pipestone Lake, about a mile west of Stone-dam Portage, there is another of these dykes cutting transversely schists which have a strike of N.E. to E.N.E. The specimen taken Pipestone Lake dyke.

Fig. 12. Section of diabase, from Pipestone Lake dyke, showing large poly somatic grain of augite in three granules of diverse orientation *a b c*; *d*, uralitic-hornblende; *e*, magnetite. × 28.

from the middle of the dyke has the characters of an uralitic quartz diabase. The felspar, as a rule, is remarkably fresh, and occurs in the usual lath-shaped twinned crystals of plagioclase. The crystals are commonly observed to be cracked transversely and the cracks filled with a brownish-yellow material which shows aggregate polarization. The augite occurs more commonly in polysomatic masses than in simple individuals. The magnetite is often surrounded by rims of secondary

brown mica. The quartz is apparently original and has numerous inclusions of an opaque granular character, together with fluid inclusions with dancing bubbles, gas pores with black borders and glass (?) inclusions oval and circular.

Dyke on S. shore of North-west Bay.

On the south shore of the North-west Bay of Rainy Lake, a similar dyke cuts both the biotite gneiss of the region and the red granite which is intrusive through it. It is an uralitic quartz diabase. The felspar is in rather stout crystals in the coarser grained part of the dyke, though usually lath-shaped. It is much decomposed and is partially replaced by quartz and chlorite. The polysomatic character of the augite is not prominent, but this may be due to the fact that it is about half altered to hornblende and to chlorite. The augite individuals are often twinned and the cleavage traces are usually well defined. The magnetite shows a tendency to peripheral arrangement around the altered augite indicative of its secondary origin. Quartz is present which is probably original besides that which is clearly secondary. Apatite in long slender needles and leucoxene in irregular masses, are the accessory constituents.

In the same dyke, nearer the contact where the texture is fine-grained, the rock is much more uralitized, traces of augite being observable only in the cores of the green compact hornblende, which has almost entirely replaced it. Apatite appears more abundant, as do also the secondary quartz and chlorite. Garnet of a pale yellowish color occurs sparingly.

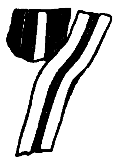

Fig. 13. Plagioclase from diabase dyke, North-west Bay, Rainy Lake, showing effect of pressure of one crystal against another.

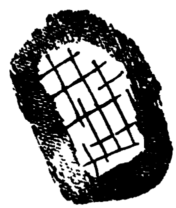

Fig. 14. Augite from diabase dyke, North-west Bay, Rainy Lake, showing marginal alteration to green compact hornblende with an encircling wreath of secondary magnetite.

At the contact the dyke rock is a compact aphanitic base in which can be detected minute porphyritic crystals. Under the microscope the base is seen to be made up of minute lath-shaped crystals of fresh plagioclase, augite grains, magnetite and chloritic substance. The porphyritic crystals are lath-shaped felspars occasionally broken and showing the lamellæ in some instances bent, as the result of pressure of

one individual against an angular part of another, and augite generally surrounded with an irregular border of secondary hornblende, which, in turn, has an outer girdle or wreath of granules of magnetite that have separated out in the process of uralitization as in Fig. 14.

On the lake, near the extremity of Gash Point, one of these dykes cuts the schists with a strike of N.W. and S.E. across the whole breadth of the point and traverses the islands on both sides of it. Here it is traceable on the point and on the islands for the distance of a mile. Three miles to the south-east in the line of the strike of the dyke, a dyke occurs cutting the schists on the islands off the south shore of the lake which is probably a continuation of that of Gash Point. From this point it is traceable for two miles across the islands to the main shore on the south side of Grassy Narrows. Thus, this dyke has a length of at least six miles and has an extension to the north-west and south-east of the points observed, for a distance that is probably very much greater. A specimen from the central part of this dyke, proved, on examination, to have the characters of a uralitic quartz-diabase. The plagioclase occurs in long, rather stout, lath-shaped crystals, which are generally so cloudy as to obliterate the twinning in most cases. The augite occurs both in simple individuals and in polysomatic masses. It exhibits the usual marginal alteration to hornblende, and there is besides a certain amount of chlorite. Original magnetite is frequently surrounded by a margin of secondary biotite. Micro-pegmatitic quartz is abundant. It is often intimately intergrown with the felspar, and, as the latter is much decomposed, would seem to replace it as a partial pseudomorph, but apatite needles of the same aspect as those which occur as inclusions in felspar, augite, and quartz, are often seen to be inclosed

Gash Point dyke

Grassy Narrows dyke.

Fig. 15. Polysomatic grain of augite—Grassy Narrows Dyke, Rainy Lake, *a* and *b* are twins—the other granules are of diverse optical orientation. × 28.

partly in a felspar and partly in quartz grain. The primary origin of the quartz, in spite of its micro-pegmatic character, is however, not beyond doubt. It is to be noted that were the quartz original we would hardly expect to find it in such close association with the felspar. The plagioclase of these rocks affords unmistakable evidence

Origin of quartz

in its idiomorphic character of its having first crystallized from the magma. The augite crystallized next, enclosing the lath-shaped plagioclase; and the quartz, which would be last to crystallize, we would expect to find separated from the plagioclase by the augite, *i.e.*, to fill in the interstices between the augite. Again, although single apatites are often found extending from a quartz grain to a felspar grain, a condition of things favoring the notion of a common primary origin of both the latter minerals, yet such a phenomenon is not incompatible with a secondary origin for the quartz, since the replacement of felspar by quartz must necessarily be a slow operation and proceed particle by particle. Further, if the quartz were original we should hardly expect to find in it inclusions of crystals of the first generation like apatite, which would be liable to be enclosed, for the most part, in the earlier secretions like felspar and augite, rather than in the residual silica of the magma. The non-existence, however, of quartz in some diabases which are very much decomposed and its presence in fresh ones, militates against the theory of the secondary origin of the quartz in these rocks, so that the question of how much of the quartz is primary and how much secondary in an old diabase is a question that as yet does not appear to be susceptible of definite settlement.

Rat-root Bay dyke.

About a mile to the west of this dyke where it crosses Grassy Island is another nearly parallel dyke converging on the former at a small angle towards the south. The rock is an uralitic quartz diabase and in its coarser portion, near the middle, the texture is more granular than that of typical diabase. The plagioclase is cloudy with decomposition products, and quartz is abundant. The augite is entirely replaced by compact green hornblende the only indication of the augite that remains being the light colored character of the central portion of the hornblende and the abundance of magnetite granules that have separated out in the process of alteration. Apatite occurs in slender hexagonal needles, mostly in the quartz, but also in the felspar and hornblende; and a number were observed which were common to both felspar and quartz. A few zircons showing parallel extinction, deep black border and brilliant polarization colors, also occur. A few colorless, rounded, isotropic grains, probably garnets, were observed. Nearer the contact where the rock is much finer grained the typical diabase structure is much better developed, the felspar having its usual lath-shaped character, with augite in allotriomorphic structure around it, although the character of the latter is obscured by its extensive alteration into hornblende. The augite so far as revealed in the cores of the hornblende occurs both in simple individuals and in polysomatic masses, and it is interesting to note that the hornblende derived from a polysomatic aggregate of augite is of

Microscopic characters.

uniform orientation throughout. Magnetite or titanic iron with associated leucoxene is generally distributed. The quartz is in small grains proportioned to the finer grained texture of the rock. In the central part of the dyke the quartz is in large grains commensurate with the increased size of the felspar and augite. In neither case does it occur in the mosaics which are so characteristic of the secondary or vein quartz. In addition to the minerals enumerated in this part of the dyke, there is in prominent porphyritic development an altered rhombic pyroxene. The alteration has proceeded very far and the mineral is now represented only a mass of yellowish green serpentine with perhaps some of the intermediate alteration product bastite. The cleavage is, however, well defined and the extinction in the several cases noted is sharply parallel to it. These characters together with the traces of the obtuse dome so characteristic of sections of enstatite are sufficient to identify it as that mineral in an altered state. The occurrence of the enstatite in this dyke in its finer grained parts towards the contact is analogous to, and an interesting confirmation of, the similar occurrence of the mineral noted in the Jack-fish Lake dyke also in the vicinity of contact.

Rhombic pyroxene.

To summarise, the main points of interest are, briefly: 1. Post Archæan age of dykes. 2. Their problematic relationship to traps of Animikie and Keweenawan. 3. Their uniform strike and arrangement in lines indicative of great lines of fissure. 4. Sharp contact. 5. Passage from coarse texture at centre to aphanitic at sides. 6. Granular character towards centre, porphyritic at sides. 7. Prevalence of quartz and garnets towards centre and absence near contact. 8. Presence of enstatite at sides, absence towards centre. 9. "Chloritic substance" abundant at sides, absent towards centre. 10. Polysomatic character of augite thoughout. 11. Uralitization of augite. 12. Very marked contrast of texture of two different parts of a rock which solidified under practically the *same pressure* but at *different rates of cooling.*

Summary.

Glacial Phenomena.

What was said of the glaciation of the Lake of the Woods in my report of 1885 is generally true of the Rainy Lake region. The whole country has been swept, grooved and polished by glacier ice. Towards the south, the surface has been covered by a great sheet of post-glacial fresh-water deposits, but north of the area over which these are distributed, wherever the glaciatod rocks are exposed, the surface is hummocky, being made up of *roches moutonnées* and long rounded ridges

Aspect of rock surfaces.

which follow the strike of the rocks of the country. In spite of this hummocky character, the surface of the country is essentially that of a flat plateau with a gentle slope to the south-west. The most prominent features resulting from the glaciation are the grooves and striæ which so constantly mark the surface of the *roches moutonnées*, and the heaps of boulders which are so abundantly strewn upon portions of their slopes. These boulders are all of Archæan and northern origin, and are all that remains of the glacial drift. All the finer kinds of drift, such as till, sand, pebbles, &c., appear with the exception of occasional remnants to have been swept down into glacial or post-glacial lakes and spread out into strata by the action of their waters. As on Lake of the Woods, those slopes which have been in the lee of the glacial current or flow have a greater accumulation of these boulders resting upon them than have those slopes exposed to its impact. Subjoined is a list of the observed direction of the ice grooving and striation at various localities. The list may seem somewhat lengthy, but it only represents an average of one observation to about every 16 square miles of the area mapped on the Rainy Lake sheet. The direction of the glacial grooves and striæ is very constantly south-westerly. The direction of the ridges and valleys of the country is quite independent of the direction of the ice flow as indicated by the grooving, and is dependent almost entirely upon the strike of the rocks as above stated. Where the strike of the rocks and the consequent trend of the ridge has been transverse to the general flow of the glacier there appears to have been little or no deflection from its mean course; but where the ridges have made a small angle with the mean course of the glacier movement, the lower portion of the glacier seems in some instances to have suffered deflection to the extent of this angle, and to have flowed in the direction of the ridges and their accompanying valleys till a change in the strike permitted its falling into line with the general flow. The average direction of the glacier movement over the Rainy Lake region as indicated by the grooving is about 40°, as compared with 45° on the Lake of the Woods, a deflection towards the meridian as we pass south-eastwardly which is probably associated with the more easterly trend of the height of land to the eastward of Lake of the Woods.

Grooves and striæ.

Distribution of boulders.

Direction of ridges and valleys independent of glaciation.

Average direction of glacier movement.

LIST OF DIRECTIONS OF GLACIAL GROOVES AND STRIÆ.

Kishkutena Route.

Kahtimi-agamak Lake	S. shore,	1 m. E. S. E.	of outlet	53°
"	"	1½ m. E.	"	58°
"	W. "	½ m. N.	"	46°

Clear-water Lake, 1 m. S. W. of north end	33°	Bearings of glacial grooves and striæ.
" S. E. shore opposite Hazy Point	53°	
Minomin River, ½ m. W. of entrance to Lake Despair	33°	
Hope Lake, N. side, ¾ m. W. N. W. of North-west Bay Portage	36°	

Pipestone Route.

Crow Lake, 1 m. N. W. of Crow Portage	39°
" 1¾ m. N. E. of "	44°
" 1¾ m. S. E. of Chase Point	36°
" west side of Shanty Point	42°
" north side of "	49°
Schist Lake, 1 m. N. W. of outlet	23°
Yoke Lake, north end	48°
Pipestone Lake, ½ m. N. W. of Unde Rapids	20°
" ¼ m. W. N. W. of Fisher Island	29°
" ¾ m. west of "	20°
" bottom of James Bay	37°
" Gates-ajar Narrows	27°
" ¾ m. E. of north end of Corner Island	44°
" N. W. side of Line Bay	41°
" 1 m. N. E. of Stone-dam Portage	44°
" 1 m. S. W. of " "	44°
Loon Lake, mouth of Whistle Bay	44°
Jack-fish Lake, ½ m. S. of Two Lake Narrows	24°
Foot-print Lake, 1 m. N. W. of outlet	25°

Kaiarskons Route.

Bluff Lake, 1¼ m. S. S. W. of north end	28°
Strawberry Lake, S. side ¾ m. from E. end	38°
" " 1¼ m. " E. "	48°
" at outlet	39°
Strawberry Creek	53°
Sucker Lake, E. side, ¼ m. S. of outlet	33°

Manitou Route

Grant Lake, N. E. end	38°
Missus Lake, S. shore, 1 m. E. N. E. of west end	48°
" " ¼ m. " "	43°
Manitou Lake, W. side, 1¾ m. N. E. of Paddle Portage	48°
" " 1½ m. S. S. W. "	28°
" S. E. side, 1½ m. N. E. of Snare Portage	53°
" " 2¼ m. E. of Pickerel Rapids	44°
" S. W. end	44°
Pickerel Lake, entrance to Mirror Bay	34°
" ½ m. N. N. E. of entrance to Mirror Bay	36°
Manitou River, ¼ m. S. W. of Porcupine Rapids	33°
Famine Point, Sphene Lake	33°

Little Canoe River Route.

Bearings of glacial grooves and striæ.

Bat Lake, 1¾ m. S. E. of portage to Three Island Lake	26°
Respite Lake, S. end	28°
" W. side	31°
Vane Lake, E. side, ¼ m. N. N. E. of outlet	33°
Little Canoe River, 1 m. N. of mouth	40°

Big Canoe River Route.

Dog-fly Portage	43°
Vista Lake, N. end, W. side	30°
Pickwick Lake, ¾ m. from N. end	23°
Sam Weller Lake, 1½ m. N. E. of outlet	38°
Obikoba Lake	33°

North-west Bay of Rainy Lake.

Two miles S. of Gusty Point	50°
Rocky islet, ¾ m. E. of Indian Falls	33°
S. shore, 1 m. E. of Gusty Point	37°
N. shore, 1¾ m. N. E. "	48°
S. shore, ½ m. W. of Camp Narrows	48°
" ¼ m. N. of Cliff Narrows	38 & 48°
" ¾ m. N. E. "	45°
" entrance to Brown Inlet, E. side	38°
Brown Inlet, E. side	44°
N. shore, opposite Brown Inlet	50°
Hanging-stone Point	46°

North Arm of Rainy Lake.

Island, 1¼ m. N. E. of Hanging-stone Point	53°
West side, 1¾ m. W. N. W. of Standing-stone Point	28°
Alfred Point	23°
West side, 1 m. W. N. W. of Standing-stone Point	38°
" 1 m. " Hook Island	28°
" 1¼ m. S. W. of Alfred Point	28°
" 1 m. " "	28°
Island, ½ m. N. N. W. of Hook Island	25°
Entrance to Grassy Narrows Bay	36 & 45°
East end of Hook Island	23°
Shoe Bay, north side	38°
Island, opposite Shoe Bay	38°
West shore, ¾ m. N. of entrance to Stanji-koming Bay	30°
East shore, Ami Point	43°
Macdonald Inlet, north side, E. of Big Canoe River	33°
" " 1½ m. E. "	38°
Blaze Point	40°

Bearings of glacial grooves and striæ.

Hopkins Bay, 1 m. E. of Blaze Point	46°
" 1½ m. " "	35°
" 2 m. E. "	48°
" 3 m. E. "	32°
" bottom of bay	45°
" S. E. shore at 3 diff. points	44°
Reef Point	28°
Point, 1 m. E. S. E. of Reef Point	38°
Shore, 1½ m. S. E. of Reef Point	36°
Entrance to Stanji-koming Bay, north side	40°
" " " south side	28°
Stanji-koming Bay, E. shore	31°
" " W. shore, 2¼ m. from S. end	30°
" " " 1¼ m. " N. "	18°
" " island, 1½ m. from N. end	35°
Hay-marsh Bay, N. side	48°
Island, ½ m. E. of Squall Point	31°
Squall Point	43°
Sand Bay, small island	36 & 43°
" 1½ m. N. of Pither's Point	43°

Turtle River Route.

Turtle River, 1¾ m. N. N. W. of Jones Lake	44°
Big Turtle Lake, N. E. end of large island	35°
Robinson Lake, W. side, near N. end	42°
" " ¾ m. N. N. W. of outlet	43°
Heron River, half-way from mouth to Heron Lake	46°
Heron Lake, W. side, 1¼ m. N. N. W. of outlet	53°
Little Turtle Lake, at mouth of Little Turtle River	53°
Little Turtle Lake, S. shore, ¾ m. E. of Portage to Bad Vermilion Lake	63°
" " " 3 m. from S. W. end	63°
" " " 1 m. "	61°
Sand Island River, Otter Falls	33°
Redgut Bay, 2½ m. S. W. of mouth of Otukamamoan River	48°
" 3¼ m. " " " "	42°
" Porter Inlet, 2¼ m. N. E. of entrance	23°
" " 2½ m. E. N. E. "	43°
" W. shore, ½ m. N. of Pine Narrows	33°
" west side Pine Narrows	43°
Black Sturgeon Lake, S. side	23°
Redgut Bay, 3 m. N. of Bear's Passage	28°
Bear's Passage	50°

Seine River Route.

Seine River 1 m E. of Partridge-crop Lake	56°
Wild Potatoe Lake E. end	36°
" " " S. shore 1¼ m from E. end	48°
" " " S. shore at narrows	50°
" " " N. shore at "	40°
" " " S. " 1¼ m W.S.W. of narrows	48°
" " " S. " at outlet	58°

Bearings of glacial grooves and striæ.

Shoal Lake N. side 1 m from E. end	45°
" " S. side 1½ m " W. "	53°
" " N. " near outlet	53 & 63°
Seine River opp. Kettle Pt.	46 & 60°
" " ¾ m from mouth	53°
Bad Vermilion Lake, Island Bay	40°
" " " N. shore 3 m from S. W. end	48°
" " " S. " 2 m " " "	53°

East Arm of Rainy Lake—Pither's Point to Seine River.

South shore 1 m E. of Pither's Point	48°
" " 2 " " "	48°
Island 3 " " "	33°
Island ¾ m N. of Medouganak Point	33°
Medouganak Point	46°
Entrance to Black Bay W. side	48°
Lobstick Island	53 & 28°
Island S. of Gash Point	38°
Main shore N. of Lobstick Island	41°
Cross Island	43°
Main shore W. of Lichen Island	48°
Rocky Islet Bay, W. side 1½ m N. of entrance	36°
Rice Bay, at entrance S. E. side	53°
" " N. W. side 1 m. S.W. of narrows	48°
" " near bottom	48°
" " 1 m. E.S.E. of narrows	57°
Grassy Portage Bay, 1¾ m W. of Grassy Portage	53°
Island 1½ m. E. of Last Island	40°
" 1 m. E.N.E. of Last Island	43°
Pukamo Island E. end	53°
Island ½ m E. of Cross Island	41°
Nowhere Island N. side	43°
Island 1 m. N. of Red Sucker Island	38°
Red Pine Island S. side	48°
Sand Point Island S.W. end	43°
Dryweed Island E. end	48°
Sand Point Island at Open-water Narrows	48°
Goose Island S.E. point	48°
Rest Island S. end	38°
Goose Island W. end	48°
Berry Island S. side	43°
Little Rocky Narrows	43°
Swell Bay S. side 1½ m N.W. of Little Rocky Narrows	48°
Swell Bay E. end	51°
Island 3 m W. Halleluiah Point	48°
South shore, 2½ m W. of Brûlé Narrows	53°
Bleak Bay, E. end	56°
Seine Bay, N. side opposite mouth of Seine River	53°
Seine Bay, bottom of bay	58°
Halleluiah Point	61°

Rainy Lake—Brûlé Narrows to Kettle Falls.

Bearings of glacial grooves and striæ.

Island ½ m S.W. of Point Observe	73°
" 2½ m S.W. of " "	63°
" at bottom of Saginaw Bay	63°
Shore ½ m S.W. of Pine Islands	60°
Lobstick Point	33°
W. shore opposite Oak Point Island	28°
Kettle Falls	38°
S. shore 1 m W. of Soldiers' Portage	33°
Soldiers' Portage	33°
W. shore opposite Oak Point Island	33°
W. shore ½ m N.E. of Oak Point Island	36°
Stokes Bay, south side	58°
Mouth of Pipestone River	33°
Pipestone River, 5 miles up stream	53°
" " 6 " " "	43°
N. shore 2 m N.N.W. of entrance to Stokes Bay	43°
Breezy Island	40°
N. shore 1 m N. of Breezy Island	43°
Vague Point	48°
Shore, ¾ m N.W. of Vague Point	55°
Mouth of Rat River	58°
Shore 1 m W. of mouth of Rat River	59°
Shore 3 m N.W. of Deer's Horn Point	60°
Brûlé Narrows E. side 1 m N.E. of Pt. Observe	53°

Rainy River.

Island 4 m above Manitou Rapid	38°
S. side 1 m below Longue Sault Rapids	24°
Pine River, first rapid	24°
" " second rapid	24°
South side ½ m above mouth of Rapid River	38°

POST-GLACIAL FORMATIONS.

Rainy River, from its source at Rainy Lake to its mouth on the Lake of the Woods, flows through a country which is thickly covered by post-glacial formations. The earliest notice of scientific value, which I have been able to find of these post-glacial deposits, is that by J. J. Bigsby, M.D.,* who remarks that "throughout the whole length of the river La Pluie, its banks expose a grey clayey and loamy soil, full of small angular fragments of the yellow limestone of the Lake of the Woods, intermixed occasionally with round lumps of gneiss from the size of the fist to that of the head. I saw no marks of stratification, nor any marine or fresh water shells." J. E. Norwood, M. D.,† in run-

Previous notices.

Bigsby.

Norwood.

* Geol. Jour., Vol. VIII., 1851, p. 217.
† Report of Geol. Survey, Wisconsin, Iowa and Minnesota, by D. D. Owen, 1852, p. 319.

ning down the river from Rainy Lake to the Big Fork, noted that "while descending Rainy River, a bed of blue clay was observed similar to that seen and described on St. Louis and Embarras rivers. It is full of gravel and overlaid by a bed of yellow sand." S. J. Dawson* also has noted that "the land immediately bordering on Rainy River, on the British side, is of an alluvial description, and almost as uniformly level as the prairie at Red River."

Dawson.

Bell.

Dr. Bell † states that "the banks of the Rainy River, except in approaching the Lake of the Woods, are generally from fifteen to twenty feet high, and are composed of clay and drift materials in which pebbles and boulders of a yellowish grey limestone are plentiful."

These brief notes by earlier observers of the formations through which Rainy River cuts its way, do not give a sufficiently clear or comprehensive account of their character, their distribution or their geological history. I shall, therefore, attempt to supplement them by observations I have been enabled to make in the field myself, as well as to point out the connection of the facts adduced with those that have been observed by others in the study of post-glacial phenomena in adjoining regions. I am at a loss to understand Dr. Bigsby's statement that he saw no marks of stratification in the banks of the river. There are abundant and distinct evidences of the deposition of the greater part of the formations in stratiform layers or beds. They are first observed on Rainy Lake on the west shore of Sand Bay, as bedded clays. Between Rainy Lake and Fort Frances, the banks of the river are composed of light colored, more or less, sandy and calcareous clays with numerous pebbles of yellow or cream-colored limestone. The banks rise about ten or twelve feet above the surface of the river at its mean height, and the country back from the river is flat. Below the Falls of Fort Frances the river sinks in level, between 22′ and 25′. And as the surface of the country remains flat, the height of the river banks below the falls is increased by this amount. The banks here present a more or less steeply scarped aspect, a character which they retain almost continuously to the mouth of the river, although there are occasionally short stretches of sloping banks or low shores which are wet or dry, according to the height of the water in the river. For a long distance down the river from the falls, evidences of stratification are not very prominent in the banks. The clay is very calcareous or marly, and crumbles readily when dry, forming a steep talus. The bedding can, however, be seen occasionally in the short scarp which rises above this talus quite distinctly. In these cases, thicker beds of a calcareous

Evidence of stratification.

Character of beds.

Steeply scarped banks.

* Report on the exploration of the country between Lake Superior and the Red River settlement. Appendix to Vol. XVII. of the Journals of the Legislative Assembly. Session 1859.

† Report on the country between Red River and the South Saskatchewan, with Notes on the Geology of the Region between Lake Superior and Red River, 1873.

or sandy clay, with numerous small pebbles, are generally separated by thin partings of purer unctuous clay. The thicker beds usually vary from 2″ to 6″ in thickness, and are often much more sandy than clayey. For the first three miles below the falls, the underlying glaciated rocks upon which the formation rests crop out occasionally on both sides of the river. From these exposures I should judge that the mean level of the rocky surface of the country along this part of the river would be but little below the surface of the river, and that we have in the height of the banks a vertical section nearly equal to the mean thickness of the formation which would, therefore, be between 30′ and 40′. After turning the bend three miles below Fort Frances, no rocks crop out along the river for over twelve miles. Throughout this distance, the character of the banks varies but little and presents only a few points of special interest. On the Indian Reserve opposite the mouth of Little American or Little Fork River there is a peculiar terrace-like ridge running parallel with the river a few hundred feet from the water's edge. It is observable only for a short distance where the Indians have cleared away the bush. Between the Little and Big American Rivers on the Canadian side there can be seen an extensive, apparently unstratified mass of clean, unctuous, blue clay underlying the bedded marly clays and sands of the upper portion of the bank. Below the Big American River the bedded clays, sandy and marly clays and sands prevail, and the lower unstratified blue clay was not again observed for a considerable distance. On Mr. George Singleton's farm, (Sec. 9, Tp. 5 S. R., XXVIII,) the glaciated surfaces of the old rocks outcrop from beneath these post-glacial deposits, not only on the river banks, but over a considerable area in the rear of his farm, the rock being a hornblende-syenite gneiss. Rock exposures are more common from this point on to the bottom of the Longue Sault than anywhere else along the river, and some of the more prominent points appear to have been islands in the fresh water lake, in which the post-glacial formations were deposited. The latter cannot be on the average much more than 25′ or 30′ thick along this part of the river. The surface of the country rises gently, however, on the north side of the river, and at the back of Mr. Lutterel's farm, Sec. 22, Tp. 5, S. R. XXVIII, a low flat gravel ridge was observed which probably lies on top of the beds exposed at the river bank. Between this point and Manitou Rapid many more boulders of Archæan rocks were observed imbedded in the strata of the river banks than had been noticed higher up the stream, although they are not prominent near the rapid itself, the formation, as observed by Dr. Bigsby,* being unusually clayey there. Near the eastern limit of the Indian

Thickness of formation.

Terrace-like ridge.

Blue clay.

Rock exposures.

Gravel ridge.

Unbedded clay.

*Loc. cit.

Reserve at Manitou Rapid there may be seen on the north side of the river a mass of unbedded clay with pebbles to a thickness of 10′ to 15′ above the surface of the river, and resting upon this 4′ of evenly bedded sandy clay in which the pebbles are mostly yellow colored limestone. Down near the rapid these upper beds are wanting just at the water's edge and the lower clay only is seen. This lower clay is probably the same formation as that noted between the Big and Little American rivers.

Beds below Longue Sault. Below the Longue Sault Rapids for some miles the banks of the river on either side, wherever the scarped faces permit of close observation, shew only bedded marly clays, and clayey sands with pebbles. If the unstratified lower clay underlies these beds, as appears quite probable, it is concealed by the soft talus that has fallen from the scarp. **Well.** Mr. Cameron informed me that he had sunk a well four miles back from the river on a logging road, Sec. 21, Tp. 4, S. R. XXV., for 22′, and had bored a further 40′ through formations similar to those on the bank of the river before he struck solid rock. He obtained water at this depth of 62′, but found it extremely hard, a fact due to the abundance of calcareous matter in the loose strata through which water must percolate before reaching the comparatively impermeable surface of the underlying hard rocks. **Pine River.** The formations up the Pine River, as far as the second rapid, are, as on Rainy River, bedded marly clays and clayey sands together with gravel made up very largely of limestone debris. At the first rapid on Pine River a gravel ridge which lies on the glaciated surface of the rock has been cut into by workmen engaged in the construction of a dam across the rapid. The gravel is rather fine, mostly calcareous, and much mixed with clayey matter. **Remains of Buffalo.** In it were found large numbers of fresh water-shells together with some fragments of bones of the buffalo (*Bos Americanus*, Gmelin.) Fresh-water shells were also found in the beds on Rainy River, at the confluence of Pine River, and at various points below this, particularly, however, in the bedded sands and clays at the mouth of Beaudette River. Although the shells at these points are numerous, the species are few. The following have been identified by **Freshwater shells.** Mr. Whiteaves, *Sphærium sulcatum*, Lamark; *Sphærium striatinum?* Lamark; *Planorbis (Helisoma) bicarinatus*, Say; *Limnæa (Limnophysa) desidiosa ?* Say (one, broken). Near the confluence of Beaudette River and from that point on to the mouth of Rainy River, the banks still retain their abruptly scarped aspect rising from 10′ to 20′ above the river, but the formations composing them gradually change in character, and the clay gives place to a fine light-yellow muddy sand, bedded often with very thin partings of clay. A third of the way from Beaudette River to the mouth of Rainy River, this yellow sand is

observed to rest upon a pebble conglomerate made up of limestone and Archæan pebbles imbedded in a partially hardened mud matrix. Conglomerate.

At the south-east corner of the Lake of the Woods these post-glacial deposits of sand have been much modified and altogether re-arranged by the currents incident to the discharge of a large river, by the waves of a large open expanse of water exposed to the full force of the west wind, and by the wind itself wherever they are exposed above the surface of the water and unprotected by vegetation. About three miles west of Rainy River there runs out from the south shore of the lake, in a direction 65°, a sand spit three miles and a-half in length. The sand on this spit has been blown by the wind into dunes and ridges which are now partially protected by vegetation. At the extremity of this spit, on Oak Point, the main current from the river discharges into the open lake. On the other side of this gap of half a mile, through which the current sweeps, the sand spit is continued in a long barrier running parallel with the shore, or in a direction 40°, as far as Burton's Island, a distance of six miles and a-half from the gap above mentioned. Portions of this barrier are only revealed above the surface of the lake in seasons of low water, and its breadth varies according to the height of the water. It is, however, very narrow compared with its length, and is for the most part a prominent ridge standing out boldly against the sky in a series of wind-blown dunes which rise from 10′ to 40′ above the level of the lake. The sand is of a light yellowish color, and of varying degrees of coarseness. It is composed chiefly of quartz and felspar grains. In the dunes may sometimes be detected a bedding due to the action of the wind, and the process of sorting out the different sands in layers according to their coarseness and the strength of the wind, may be observed in actual operation. The channel or open lagoon, which lies between the shore and this barrier, varies in width from half a mile to a mile and is silting up on the shore side, there being, apparently, a weak side current from the river along the inside of the barrier which keeps it free of the grassy vegetation which prevails closer to shore, and which catches the fine silt in seasons of high water.

Sand-spit.

Sand-barrier.

Dunes.

Bedding due to wind.

The shore of the lake from Burton's Island north-eastward to the Indian Reserve north of the mouth of Little Grassy River is mostly sand of the same character as that of the barrier, and has been much modified by wave action. Windy Point is a long sand-spit and the island to the north-east of it partakes of the nature of a delta. The water for considerable distances off shore along this stretch of coast is very shallow. On the Indian Reserve 35 E., bedded clays similar to those on Rainy River are again observed in low scarped banks. The shore of the bay on the north side of this reserve was the most northerly point along this coast at which these deposits were observed.

S.E. shore of lake.

Bedded clays on Indian Reserve 35 E.

Further distribution of bedded clays.

Here they consist of clayey limestone gravel and marly clay in beds. The same formations occur together with much sand on Bigsby Island, and in places on the south and west side of Big Island. Their occurrence on Cornfield Island was noted in my report of 1885. West of Cornfield Island, the northern limit of the distribution of these post-glacial beds bends more to the north, for they are found on the shores of the North-west Angle Inlet, and probably underlie the extensive flat country to the south-west of the inlet and west of the Lake of the Woods. At the south end of Shoal Lake great sandy stretches occur and at the north-west corner of Shoal Lake, in the neighborhood of Indian Bay, the bedded clays are again observable. The northern limit of the flat country underlaid by these post-glacial deposits appears, from such information as I can gather from those familiar with the country, to cross the C. P. railway in the neighborhood of Whitemouth, and such deposits appear thereafter to be in direct continuity with the prairie country of Manitoba.

Country north of Rainy River.

In the country north of Rainy River it appears, from information supplied by the reports of Mr. S. J. Dawson,* Mr. T. O. Bolger,† and from the plots of the township surveys as well as from my own observations, that these post-glacial formations, through which the river cuts its way, extend back to an average distance of about twenty miles, or to a line connecting the N.W. corner of Sand Bay on Rainy Lake with the northern limit of Indian Reserve 35 E. on the Lake of the Woods.

Northern limit of post glacial formations.

Thus it appears to be possible to trace approximately the northern limit of a great sheet of post-glacial deposits from Rainy Lake to Whitemouth, a distance of 150 miles. The line defining this limit is more or less sinuous, so far as can be made out, but its general direction is remarkably straight and *has a course which is approximately at right angles to the direction of the glacial grooving* in the exposed rocky region immediately to the north of the line. This sheet of post-glacial deposits appears to extend indefinitely to the south, and from various sources of information‡ the flat country underlaid by them appears to be in direct continuity with the prairie country of western Minnesota, Dakota and Manitoba. The body of water in which these formations were deposited appears to be the same, as stated in

Lake Agassiz.

my report of 1885 with Mr. Upham's Lake Agassiz.§ According to

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* Exploration of country between Lake Superior and Red River Settlement, 1859.

† Report of Commissioner of Crown Lands of the Province of Ontario, 1886, p. 48 et seq.

‡ Reports of Progress together with a Preliminary and General Report on the Assiniboine and Saskatchewan Exploring Expedition, by H. Y. Hind, M.A., 1859. Report VII.

Geol. and Resources of 49th Parallel, G. M. Dawson, 1875, p. 212.

Information received from Mr. Thompson, who was engaged upon a preliminary survey of a railway from the mouth of Rainy River to Red River across northern Minnesota.

§ Eighth Annual Report, Geol. and Nat. Hist. Survey of Minn. 1879, p. 84, et seq.; Eleventh Report 1882, p. 137-153; also Bulletin 39, U.S. Geol. Survey.

Mr. Upham's determination of a northerly upward slope of the surface of Lake Agassiz as it approached its northern ice barrier* there would be by his estimate 150 feet of water above the present level of Rainy Lake and much more above the present level of the Lake of the Woods. This being the case, the waters of Lake Agassiz ought to have extended far to the north of Rainy Lake and Lake of the Woods, and the fresh water deposits, which I have sketched as stretching to the south of a line drawn from Rainy Lake to Whitemouth, should also extend far to the north of that line, since there is no sufficient rise of the land along the line against which the waters of Lake Agassiz could form a shore. As a matter of fact, no old beaches have been observed along the northern limit of the fresh-water formations. Hence, if Lake Agassiz stood at this elevation, the only explanation that will account for the non-continuance of the lake deposits to the north, is the supposition that the line which defines the northern limit of those formations is approximately also *the line of the ice-barrier which dammed back the waters.* Against the base of such a barrier there would be no beaches formed, since it would be in deep water, but a gradual overlapping of strata in flat layers as the ice receded. There are, however, some facts which have yet to be reconciled with this hypothesis. These are the occurrence of areas of post-glacial deposits in the country to the north, and numerous gravel ridges and other deposits which are known to exist, but have not yet been studied. In valleys tributary to Rainy Lake, such as the basin of the Seine River and that of the Turtle River, there are local deposits similar to those on Rainy River which may perhaps be regarded as having been formed in arms or bays of Lake Agassiz. These deposits appear to lack a feature which is very characteristic of the deposits along Rainy River, viz., the presence of pebbles of cream colored or yellow Silurian limestones. The northern limit of the distribution of this limestone drift has been noted by Bigsby, Dawson and myself, and it appears to be coincident with the line that has been sketched as limiting the northern extension of the post-glacial formations. The limestone pebbles and boulders, while doubtless derived in the first instance from the Silurian rocks of the Red River basin, appear on the Lake of the Woods to come immediately from the post-glacial strata in which they are imbedded. Their glacial origin is attested by the very common and distinct striation observable upon them ; which fact also attests that they have been very little water-worn since their escape from the foot of the glacier, the inference being that the clayey strata in which they are imbedded were derived largely from the same glaciers. With regard to other isolated patches of post-glacial formations, it is to be noted

Northern barrier of Lake Agassiz.

Other local deposits.

Source of limestone pebbles.

* Bulletin cit. p. 15.

that those of any considerable extent that are known, such as that near Lake Wabigoon, appear to lie on the north side of the height of land, and may have been formed at a somewhat later stage of the recession of the ice barrier, after Lake Agassiz had shrunken to a fraction of its maximum size. On this assumption the lake in which the deposits around Wabigoon were deposited would have had the height of land for its southern barrier and probably the ice for its northern. There are few facts, however, as yet to support such speculations, and they are only suggested by the analogies which the results of Mr. Upham's work naturally lead us to look for.

Economic Geology.

Prospective development.

The country mapped on the Rainy Lake and Rainy River sheets, accompanying this report, presents, in the geological features which have been described, conditions which are favorable to its development both as an agricultural and mining district of considerable importance. The lumbering industry is already fairly well established there, the greater part of the timber which is sawn at the numerous mills near Rat Portage and Keewatin being brought down the Rainy River. The fur-trade, also is an active industry, trapping being the chief occupation during the winter months of the numerous bands of Indians who inhabit the country, while in the summer they support themselves by fishing, shooting and rice-making.

Agriculture.

Agriculture is perhaps the most promising of the economic prospects of the region. Rainy River, from its source at Coutchiching to Hungry Hall, flows for eighty miles through a rich alluvial plain, which, so far as can be judged from the banks of the river, is eminently adapted to support a large agricultural population. Travellers and explorers vie with one another in praising the beauties of the river and its capabilities for settlement. Mr. S. J. Dawson in his "Report on the Exploration of the Country between Lake Superior and the Red River settlement" says of it, "The distance from Rainy Lake to the Lake of the Woods, following the windings of the stream, is about eighty miles, and throughout the whole of this extent the land fronting on the river is fit for settlement without, I may say, a single break; indeed, I have never seen anything to equal it in my experience, except at Swan River and on the Assiniboine. Farther inland, although the ground becomes in many places swampy and broken, there must be a fair proportion also fit for settlement, but to ascertain anything like the precise area that is so, would require a closer examination than we have as yet been able to bestow." Prof. H. Y. Hind in his account of the country examined by the same expedition says of the land along

Mr. S. J. Dawson's opinion.

Rainy River: "The average breadth of superior land for a distance of seventy miles might perhaps, with propriety, be assumed to be not less than six miles, giving an area of available soil of high fertility, exceeding two hundred and sixty thousand acres; and there can be little doubt, that with the progress of clearing, much that is now included in the area occupied by swamp, would, without difficulty or expense, be reclaimed." In another paragraph the same authority says: "No part of the country through which we have passed from Lake Superior northwards can bear comparison with the rich banks of the Rainy River thus far. The river has preserved a very uniform breadth, varying only from about 200 to 300 yards. The soil is a sandy loam at the surface, much mixed with vegetable matter. Occasionally, where the bank has recently fallen away, the clay is seen stratified in layers of about two inches in thickness, following in all respects the contour of what seems to be unstratified drift clay below. Basswood is not uncommon, and sturdy oaks, whose trunks are from eighteen inches to two feet in diameter, are seen in open groves, with luxuriant grasses and climbing plants growing beneath them."

Prof. Hind's opinion.

A more recent authority is Mr. T. O. Bolger, P.L.S., who explored the region in the summer of 1886, for the Department of Crown Lands of Ontario, with the special object of ascertaining its fitness for settlement. His description and opinions are more valuable than the preceding, and they are even more optimistic. He says: "I first encountered good land at the point where the forty-ninth parallel or the first base strikes the Lake of the Woods, and following up Little Grassy River, which empties into the lake, a couple of miles south of this point, I found, from travelling in every direction, that the block of four townships composed of townships one and two south, ranges twenty-three and twenty-four east, contains a large percentage of the finest land I have ever seen, and the same description applies to the block of land lying westward between these townships and the Lake of the Woods. Little Grassy River is navigable for canoes for a distance of about eight miles from its mouth, and the land on the shore is all good, being composed of a rich calcareous drift formation, equal to any soil in the best agricultural districts of Ontario.

Mr. Bolger's description of soil of Rainy River country.

Little Grassy River.

"The timber along the river is chiefly large thrifty poplar, mixed with some scattering oak and swamp elm, and some evergreens such as balsam and spruce; inland, the timber changes in character somewhat from that along the river shore, as large balm of Gilead, spruce, balsam and tamarac are met with more frequently, and the nice open bush which prevails along the river banks is changed for a tangled brushy undergrowth; but the character of the soil remains the same. Tamarac and spruce swamps occur frequently in this section of the country, as

Timber on Little Grassy River.

is the case all through this large level area of good land which lies along the banks of Rainy River. These swamps were all perfectly dry this summer, and are nearly all capable of being made into excellent land by drainage, as they lie nearly as high as the surrounding dry lands, and only require proper ditching to take the surface water off in wet seasons. The extreme levelness of the country causes the presence of so much swamp land here, as the surface water has no means of escaping from the low-lying portions, and consequently the growth of moss and swamp timber is engendered. I noticed that in most cases the beds of the little streams are deep enough to form outlets for ditches and drains, and these creek beds are usually so numerous that to drain any swamp no very long ditches would be required; in nearly all the swamps through which I passed I observed the soil to be a black vegetable mould, varying in depth from one to three feet, and always underlaid by the same calcareous clay above alluded to. I seldom met the muskeg proper, that is to say, the wet shaky bog in which water is present at all seasons of the year, and which grows nothing but dwarf spruce and moss. I then paddled up Rainy River, and on both shores I found the same kind of country as I have described as being in the vicinity of Grassy River, and as there are a good number of settlers along the river on the Canadian side, I had an opportunity to observe the soil while under cultivation, and to see the kind of crops it is capable of raising.

Swamps drainable.

"The soil I found to be most excellent in character, calcareous clay overlaid by a thin streak of whitish fine earth about six inches in thickness, and this again covered with a coating of vegetable mould, and these three mixed up together in the working of the land form a soil which cannot be excelled in any part of the Dominion. I saw along the river crops of potatoes, turnips, hay, oats, wheat, corn, tomatoes and cabbage, all grown to perfection this season, which shows that the climate, as well as the soil, is suitable to successful farming, especially when tomatoes ripen as they certainly did this year as well as I ever saw them ripen in the vicinity of Lake Ontario.

Soil.

Crops.

"As I went up the river I frequently travelled inland several miles, and at the easterly side of township three, range twenty-four, I penetrated northward to the section I had explored from Grassy River, and found that the calcareous clay formation extends at this point clear from the Lake of the Woods to Rainy River, a distance of over twenty miles in a straight line; I found a tremendous bush fire raging along the first correction line south, which was destroying everything before it; in fact bush fires were very frequent in this part of the country this season, owing to the extremely dry weather. There is an area of pine land in here a little north of the first correction line south, where

Pine.

the soil is inclined to be sandy, but the extent of this tract is not very large.

"Along the line dividing ranges twenty-six and twenty-seven the good land extends back some twelve miles from the river, but towards the north-east corner of township three the rough regions begin to appear, and away to the northward the country is broken and rocky, and the good land disappears.

Broken country.

"Township three and the north part of township four, range twenty-seven, have been burnt over some years ago, and are now grown up with small second growth of poplar.

"Townships four in ranges twenty-eight, twenty-nine and thirty, are mostly all good land; while townships three in the same ranges are generally broken with rocky ridges, but contain some excellent land in the valleys among the hills; townships two, ranges twenty-seven and twenty-eight, also contain some good land, although broken by rocky hills.

"A straight line drawn from the south-west corner of the large Indian Reserve on Big Grassy River to Fort Frances would approximately form the north boundary of the good belt of land, while almost all the country lying between this line and Rainy River and the Lake of the Woods is good agricultural land. This tract of country is over sixty miles long, and averages over fifteen miles wide, and contains over nine hundred square miles, or something like six hundred thousand acres, and has a water frontage on the Lake of the Woods and Rainy River of over one hundred miles. Of this area, perhaps thirty per cent. is swamp, most of which can be drained and made tillable land, rocky ridges occur very rarely, and the soil is all a limestone clay such as I have described. No limestone rock in place has been observed, but loose limestones containing fossils are frequently to be met along the rivers, and the settlers along Rainy River pick them up and burn them into excellent lime; in fact this whole district is a glacial drift.

Extent of good agricultural land.

"The timber is chiefly poplar which grows to a great size; I have seen trees over eighteen inches across the stump and sixty feet long clear of the limbs. Balm of Gilead, too, prevails in some sections, while spruce, tamarac and balsam of thrifty growth are everywhere met with. In some places magnificent cedar abounds large enough for telegraph poles, shingle bolts, or any other use to which cedar is applied; there are some groves of pine through this section, but it cannot be called a pine country, that is, on this drift formation."

Timber on Rainy River.

Such testimony as to the character and value of the land through which Rainy River flows leaves little for me to say beyond expressing my entire concurrence in the opinions quoted as to the great suitability of the country for settlement and agriculture. Settlers are

going in gradually, and there are some excellent farms along the river front, the chief market for produce being the town of Rat Portage and the milling population between it and Keewatin. With the settlement of the question of civil jurisdiction, and the prospect of the railway which is projected to run through the valley, a more decided influx of settlers may be expected, and all the lots along the river front will doubtless soon be occupied and cleared. The river affords an easy means of access, and the levelness of the country renders roads easy to build.

Settlement.

Other patches of good land.

Other small isolated patches of flat-lying land, probably old post-glacial lake bottoms, which would be suitable for agricultural purposes occur to the north and east of Rainy Lake. One of these is on Big Turtle River, and another smaller one, now occupied by Indians, is on Seine River.

Mineral resources.

The economic value of the Rainy Lake region, as regards its mineral resources, is entirely prospective. There are no mines in the region, and extremely little search has been as yet made for mineral deposits. It is, however, quite probable that when such search is made, the various minerals will be found which are more or less common elsewhere under the same conditions as those which obtain here. The Keewatin rocks of the Rainy Lake region are the same as those in which the gold of the Lake of the Woods occurs. In them deposits of iron may confidently be looked for. Indeed on Seine River, good indications of iron ore have already been discovered, and farther up the river, beyond the limits of the region mapped, valuable deposits have been found on the Atic-okan. Iron pyrites, copper pyrites and arsenical pyrites are very common in small quantities in the Keewatin rocks and will doubtless some day be found in valuable deposits in some portion of the belt. Lead and zinc ores may also possibly be discovered. The occurrence of bosses of serpentine suggests the possibility of diamonds, and some enterprising prospector may yet be rewarded for a close examination of the vicinity of the serpentine rocks indicated on the map, or of others that may be discovered, particularly if they be found near the carbonaceous schists that sometimes occur in the Keewatin. Asbestus should also be carefully searched for in these serpentine rocks. Poor varieties were observed in veins in the serpentine of Clear-water Lake. Closer examination may reveal the finer and more valuable varieties. Good soapstone is not uncommon in the Keewatin rocks and will some day be of value. Limestone in small quantities has been observed on Manitou Lake, associated with the green schists. Good roofing-slate has not been observed, but occurs in the Keewatin series on the Lake of the Woods. Some of the more siliceous schists would make good whetstones, and the finer-textured

felsite schists good hones. The development of these various resources will, however, only come with the gradual settlement of the country, as it is only the discovery of the more valuable metals in large quantities that will create a sudden influx of prospectors and mining population.

In the dykes and irregular masses of pegmatite which break through the rocks of the Coutchiching series on the south-east arm of Rainy Lake and on Nemeukan Lake, white mica occurs abundantly, but unfortunately not often in sheets over two inches in diameter. If these pegmatites were carefully prospected, local developments of large and valuable sheets of white mica would very probably be found in paying quantities. Mica.

The Laurentian rocks of the region are, so far as they are known, perfectly destitute of metalliferous deposits, except in one instance, where, at the immediate contact of these rocks with the schists of the Coutchiching at the Bear's Passage, a quartz vein occurs in which flakes of molybdenite are common. Even in this instance it is difficult to say whether the vein is not as much in the Coutchiching as in the Laurentian, the contact of the two being a brecciated one. This remarkable barrenness of the Laurentian rocks, as contrasted with those of the upper Archæan, is a fact of great interest as well as of practical importance to the prospector. On the map accompanying this report, the distribution of the Keewatin rocks is mapped distinctly, so that prospectors for gold, or iron, or any other of the metalliferous ores, need not waste time examining the Laurentian country. Barrenness of Laurentian rocks.

The reason why the Keewatin series should be metalliferous and the Laurentian barren of metals is a theoretical question which need not be gone into at all fully here. It may, however, be briefly indicated that the fact is quite in harmony with the interpretation of the geology of the region which has been given in the earlier pages of this report. It has there been shewn that the Keewatin series is largely made up of volcanic rocks, while neither the rocks of the Coutchiching nor of the Laurentian are volcanic. From this it is inferred, as has been established in many parts of the world, that the presence of metalliferous deposits is intimately associated with the volcanic rocks. It has also been shown that the Laurentian or lower Archæan rocks have very probably resulted from the plutonic fusion and recrystallization of the floor upon which the upper Archæan was deposited, and that such fusion has included portions of the upper Archæan formations. Such fusion would effect the dissemination throughout the magma of whatever metalliferous deposits existed, so that on recrystallization, the ores would only be found in the minutest traces, while the existence of an extensive magma underlying the unfused rocks of the upper Archæan may have Theoretical considerations.

been an important factor in the production of the numerous veins found in them.

Value of post-glacial formations.

In the post-glacial formations of Rainy River, the clays, sands, and limestone boulders are all of economic value. Some of the lower blue clay seen on the banks of the river appeared to be very pure and capable of being worked for pottery. Other clays would make good bricks. Much of the sand intercalated with the clays would be serviceable for building purposes, and some of that at the mouth of Rainy River would be good for glass making. The limestone boulders are occasionally burned for lime by the settlers.